Aug. 31, 1922.] *Entered as second class matter at the New York, N.Y., Post Office, February 28, 1900* [No. 296

SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

VOL. 25. **Published Monthly.** PART 8

COPYRIGHT

Issued by the

INSTITUTION OF ELECTRICAL ENGINEERS.

SAVOY PLACE, VICTORIA EMBANKMENT, W.C. 2.

Compiled and Edited by the Institution, in association with

THE PHYSICAL SOCIETY OF LONDON

With the Co-operation of

THE AMERICAN PHYSICAL SOCIETY,

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, and the

ASSOCIAZIONE ELETTROTECNICA ITALIANA.

ABSTRACTORS.

G. E. ALLAN, D.Sc.
M. N. ALLEN, B.Sc.
C. ARNOLD.
PROF. C. O. BANNISTER, A.R.S.M.
T. BARRATT, D.Sc., A.R.C.S.
PROF. E. H. BARTON, D.Sc., F.R.S.
E. BELLINI, D.Sc.
W. G. BICKLEY, M.Sc.
H. BORNS, Ph.D.
W. W. BRYANT, B.A., F.R.A.S.
C. P. BUTLER, A.R.C.Sc., F.R.P.S.
F. T. CHAPMAN, D.Sc., A.M.I.C.E.
W. R. COOPER, B.Sc., A.I.C.
A. DANIELL, M.A.
J. S. DOW, B.Sc.
E. FOORD.
A. E. GARRETT, B.Sc.
C. S. GARRETT, D.Sc.
M. A. GIBLETT, M.Sc.
E. GRIFFITHS, D.Sc.
W. H. GRINSTED.
T. HARRIS, B.A., B.Sc., A.R.C.S.
H. H. HARRISON.
T. C. HARRISON, A.M.I.A.E.
J. L. HAUGHTON, D.Sc.
H. H. HODGSON, M.A., B.Sc., Ph.D.
A. W. JUDGE, A.R.C.Sc.
J. B. C. KERSHAW, F.I.C.
W. N. Y. KING, A.C.G.I.
J. L. LANGTON, M.Sc.
F. C. A. H. LANTSBERRY, M.Sc.
F. A. LAUPER.
A. W. LEE.
B. J. LEGGETT.
A. B. C. LICENCE.
L. LOWNDS, B.Sc., Ph.D.
T. M. LOWRY, D.Sc., F.R.S.
N. W. MCLACHLAN, D.Sc.
R. E. NEALE, B.Sc., A.C.G.I.
E. A. OWEN, M.A., D.Sc.
W. C. S. PHILLIPS, B.Sc.
T. H. POPE, B.Sc.
T. S. PRICE, D.Sc., Ph.D.
J. N. PRING, D.Sc.
W. A. RICHARDSON, B.Sc., F.G.S.
E. C. RIMINGTON.
J. ROBINSON, B.Sc., Ph.D.
S. R. ROGET, M.A.
F. R. C. ROUSE.
H. S. ROWELL, B.Sc., A.R.C.Sc.
A. RUSSELL, M.A., D.Sc.
P. E. SHAW, B.A., D.Sc.
S. G. STARLING, B.Sc., A.R.C.S.
J. J. STEWART, M.A., B.Sc.
W. H. STORY, M.A.
W. E. SWALE.
J. S. G. THOMAS, D.Sc.
PROF. F. C. THOMPSON, D.Met., B.Sc.
G. W. DE TUNZELMAN, B.Sc.
R. J. WALLIS-JONES, M.I.C.E.
J. W. T. WALSH, M.A., M.Sc
L. H. WALTER, M.A.
W. E. WARRILOW, A.M.I.E.E.
A. WILKINSON, B.Sc.
A. R. WILKINSON.
I. WILLIAMS, M.Sc.
A. B. WOOD, D.Sc.

Price, Single Numbers, 2s. 6d., or 65 cents.

Annual Subscription, 27s., or $6.75 net, including the Yearly Index,

Annual Subscription for both Sections 45s., or $11.25.

LONDON:

E. & F. N. SPON, LIMITED, 57, HAYMARKET, S.W. 1.

NEW YORK:

SPON & CHAMBERLAIN, 123, LIBERTY STREET.

1922

We make every kind of Electric Cable; insulated with Vulcanised India Rubber, Paper, Bitumen, Gutta Percha, Varnished Cambric, Cotton, Silk, etc., and with every known type of protection, for any situation or climate.

THE scientific research and testing work constantly in progress at our Factories assures to you the latest and most suitable type of Electric Cable for your working conditions. We make only Electric Cables and their Accessories. Thus we are in every sense ***specialists,*** and you get an advantage from that in the quality and fitness of Henley Cables for the work we manufacture them to do.

HENLEY CABLES

W. T. HENLEY'S TELEGRAPH WORKS CO. LTD

BLOMFIELD STREET, :: :: LONDON, E.C.2

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1922.

GENERAL PHYSICS.

1823. *Electric Chronograph, Registering in Figures the Time to a Hundredth of a Second.* **H. Chrétien** and **P. Ditisheim.** (Comptes Rendus, 174. pp. 999–1002, April 10, 1922.)—The chief difficulty in adapting the synchronised motor of W. P. Gerrish, used for driving equatorials at Harvard College Observatory, to the printing chronograph, is that of maintaining the actual velocity constant as well as the mean velocity. The synchronisation would oscillate between two values: its minimum at the moment of closing the circuit by the chronometer, and maximum at breaking the circuit by the motor. For this purpose the flywheel as employed by Gerrish is not suitable, as the synchronisation is too sluggish. The authors propose to avoid the difficulty by having two motors and arranging that when one is at its max. speed the other shall be at its minimum, so that the combined effect shall be practically constant. W. W. B.

1824. *Electro- and Radio-Geoscopy.* **U. Bianchi.** (L'Audion, 8. pp. 3–19, March 1, 1922.)—This article deals with the methods devised and realised for searching for metallic ores under the earth's surface. The methods employing the electrodynamic balance, the resistance, the chart of potentials, and Hertzian waves, are described. This last system utilises the opacity of the metallic ores when a valve transmitter is employed and a valve receiver. Many diagrams and details illustrate the article. E. B.

1825. *Pendulum Oscillations by the Photographic Method.* **P. Le Rolland.** (Ann. de Physique, 17. pp. 165–381, March–April, 1922.)—The photographic method due to G. Lippmann (and used since 1897) is, in the author's opinion, far superior to the method of coincidences. Two pendulums to be compared are both illuminated by the same electric spark. Each pendulum carries a fine index line and the image of this passes into a camera and is photographed.

As the photographic image can be made very fine its position can be found on the developed plate correct to 1/200 mm. The same photograph shows the exact amplitude of each pendulum. Knowing dis-

placement and amplitude for each pendulum we obtain the ratio of their periods, $T/T' = \omega'/\omega = (2\pi u' + a_1' - a')/(2\pi n + a_1 - a)$; where ω_1,ω' are the "angular" speeds of the two pendulums; n_1,n' the number of their complete vibrations during the period of the experiment; a_1,a' the value of arcs in $(a - b)/(a + b)$, where a, b are the distances on the photographic plate from each end of swing to the image of the index. In a case considered in which the time interval was 100 oscillations the ratio T/T' was ascertained to eight significant figures and three sets of results agreed to 1 in 1,000,000. To obtain anything like this accuracy by the method of coincidences would require measurements lasting many hours. The several advantages of the photographic method are specified.

The theory of, and possible errors arising in, pendulum measurements is set forth in detail mathematically. P. E. S.

1826. *The Retaining of Granular Substances.* **H. Lorenz.** (Zeits. techn. Physik, 3. 3. pp. 87–90, 1922.)—In a previous paper [Abs. 241 (1922)] the author developed a theory of the elastic properties of solids, on the basis of internal friction. In the case of "absolutely brittle" bodies, i.e. those for which the elastic limit coincides with the ultimate strength, it was found that rupture should occur at an angle ϕ with the stress, where $\tan\phi = \frac{1}{2}$, that is $\phi = 26° 30'$. By considering the assumptions upon which this result was based, it is seen that the same ought to be true for any loose, sandy substance, provided the grains are small compared with the whole. From this it is deduced that the angle of repose should be 36° 50′. Poisson's ratio comes out to be 5, and this is a limiting value for solids. In support of the last result, determinations by Planck on iron giving values of m increasing with the stress, to 4·93 at rupture, are quoted. W. G. B.

1827. *Experiments in Mechanics.* **H. Diesselhorst.** (Zeits. techn. Physik, 3. 2. pp. 33–35, 1922. Paper read at the Deutsch. Physikertag, Jena, Sept., 1921.)—Describes:—(1) A model illustrating the critical speed of rotation. (2) A model for demonstrating the friction in dry and lubricated bearings. (3) Two simple experiments on angular momentum and energy. W. G. B.

1828. *A Generalised Form of the Equation of Oscillatory Motion.* **W. Jaeger.** (Zeits. f. Physik, 9. 4. pp. 251–258, 1922.)—It is shown that the equation of oscillatory motion $d^2x/dt^2 + adx/dt + bx = f(t)$ involving two constants a and b can be reduced to a form involving a single parameter only. The transformation may be effected by introducing one of a number of suitable values of the independent variable t. The method is illustrated by its application to the cases of oscillations in inductive circuits, the ballistic galvanometer, etc. J. S. G. T.

1829. *Elastic Constants and Specific Heat of Regular Crystals.* **K. Försterling.** (Zeits. f. Physik, 8. 4. pp. 251–256, 1922.)—Further calculations on the deduction of the specific heat from the elastic constants and the frequency of the "Reststrahlen." The result is very satisfactory in the case of potassium bromide (rock-salt type); the calculations lead to impossible results in the case of diamond and are unsatisfactory for zinc blende. H. B.

1830. *On the Experimental Proof of the General Newtonian Mass Attraction.* **T. Wulf.** (Phys. Zeits. 23. pp. 154–157, April 1, 1922.)—The chief difficulties which attend the experimental proof for the general mass attraction are the small dimensions of the attractive forces measured on the laboratory scale, and the magnitude of the experimental errors. The present author now describes an installation, the principle of which was first introduced by Eötvös, which depends on the energy amounts communicated to an oscillating pendulum being so great that such disturbances as air currents, small shakings, etc., are so reduced as not to effect the final result and theoretical deduction therefrom. The mathematics of the method and the experimental details are discussed at length. The experiment is claimed to be very suitable for lecture purposes.

H. H. Ho.

1831. *Relativity Theory and Absolute Transport Time.* **H. Reichenbach.** (Zeits. f. Physik, 9. 1 and 2. pp. 111–117, 1922.)—The present paper is a continuation of a previous brief communication [see Abs. 254 (1922)] dealing with the axioms of relativity space-time theory. The possibility of establishing absolute time is now investigated from the following standpoint: Which axioms are compatible with such an idea and which are incompatible? A possibility of so defining the synchronism of clocks that for all systems the same simultaneity arises, is afforded by means of the transport of clocks. In this connection various axioms are examined, and the problem is restricted for simplification purposes to the special theory of relativity. The result is obtained that the idea of absolute transport time is excluded by the relativity axioms as a whole, although this exclusion depends only on axioms 8 and 10, and the idea of absolute transport time is even found to be compatible with each of these taken separately. The same separate compatibility is also found for the principle of constant light-velocity and with the Michelson experiment. It is the combination of the light and relativity principles which renders the idea of absolute transport time impossible. Axioms 8 and 10, however, have not been directly confirmed and depend on analogies, so that it is important to determine whether the Einstein clock retardation can be directly established (transversal Doppler-effect). Only in this way can the idea of transport time be empirically refuted, and should the above retardation not be proved then the subject of this paper becomes possible. A process will then be afforded of defining simultaneity in a natural way, applicable to all systems and so evolving the idea of absolute time. It has therefore to be established that either the Einstein light principle or the relativity principle is invalid for rigid rods, although this will not render false the idea of relativity time, which has been established on purely light-geometrical grounds without the aid of natural clocks and rigid rods. Since the definitions are at present arbitrary, both times have equal validity.

H. H. Ho.

1832. *Note on the Repulsion Law and the Diameter of the Nitrogen Molecule.* **R. Becker.** (Zeits. f. Physik, 9. 1 and 2. pp. 118–122, 1922.)—The author has previously shown [see Abs. 1801 (1921)] that the measurements of Amagat up to 3000 atmos. on the 0° and 15° isotherms for nitrogen are in accord with the equation $p = RT/v(1 + ke^{k/v}/v) - a/v^2 + k/v^{\beta+2}$. The measurements afford values of $k = 40 \cdot 3$ cm.^{3}/mol., $k = 384 \times 10^{17}$dyne/cm.^{2}(cm.^{3}/mol.)$^{\beta+2}$, and $\beta = 5$. For extremely high

pressures between 1000 and 3000 atmos. this equation is in remarkably good agreement with experience, but for low pressures $k = 40{\cdot}3$ is too small. The new term $k/v^{\beta+2}$ is of theoretical interest, becoming appreciable only at high densities, and is clearly an effect of the repulsion forces between the molecules. In his previous paper the author has shown by means of the virial hypothesis that actually such a term must appear in the equation of state, if it be assumed that between two molecules a repulsive force is exerted in addition to van der Waals' attraction, whose potential possesses the form $\phi(r) = b/r^n$, where b is the distance apart of the molecule centres, while b and n are constants. Owing to the great importance of this repulsion law for the as yet undiscovered model of the nitrogen molecule, further evidence is desirable. Such a proof is now afforded by the first term $RT/v(1 + k/e^{k/v}/v)$ of the first equation above, and although a theoretical foundation has not been obtained for this analytical expression, yet it is shown that between the three empirical constants k, α, β of the above equation of state, a numerical connection arises which establishes the above expression for the repulsion law. The approximation obtained between theory and experiment is found to be highly satisfactory. The molecular diameter of nitrogen is calculated at $3{\cdot}18 \times 10^{-8}$ cm., which is in good agreement with values found by entirely different methods. H. H. Ho.

1833. *On the Connection of the Tensorial Field.* **P. Dienes.** (Comptes Rendus, 174. pp. 1167–1170, May 1, 1922.)—Mathematical.

1834. *Remarkable Coincidence in Theory of Relativity.* **M. Sauger.** (Comptes Rendus, 174. pp. 1002–1003, April 10, 1922.)—Applying the Lorentz contraction to the element of space in the direction of motion; leaving the perpendicular element unaltered and correcting the unit of time for the retardation of the clock, the author obtains:

$$ds^2 = dr^2/(1 - 2Gm/rc^2) + r^2d\theta^2 - dt^2(1 - 2Gm/rc^2)$$

which is the Einstein-Schwarzschild formula for the fundamental integral in the static field of a particle. It is tempting to explain this by the principle of equivalence, that is, the motion of the body compels it to undergo the same mechanical actions as it would under gravity if at rest. The author points out, however, that the Lorentz formula applies to uniform velocity and not to acceleration, and that Newton's law from which he derived the potential, differs from Einstein's, from which the formula of Schwarzschild was derived. He concludes, therefore, that the approximations involve two equal and opposite errors which exactly balance. W. W. B.

1835. *Stationary Streaming Caused by a Body in a Fluid with Friction.* **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 24. 8. pp. 1082–1107, 1922.)—Mathematical.

1836. *Immediate Solutions of some Dynamical Problems.* **A. Gray.** (Nature, 109. pp. 645–647, May 20, 1922.)

1837. *Atomic Radii.* **M. L. Huggins.** (Phys. Rev. 19. pp. 346–353, April, 1922.)—*Physical Meaning of Bragg's "Atomic Spheres" and "Atomic Radii."*—W. L. Bragg's "atomic spheres" and "atomic radii,"

considered in the light of the Lewis theory of atomic and molecular structure, have a definite physical meaning. *The "atomic sphere" of an atom is its valence shell, and its "atomic radius" is the distance from atomic centre to a group of electrons (usually an electron pair) in the valence shell.* This idea is applied to several crystals.

Bragg's Method of Calculating Atomic Radii not always Valid.—Bragg's assumption that the distance between two adjacent atomic centres equals the sum of their radii is often not valid, since in many cases the group of electrons constituting the bond does not lie on the line joining the atomic centres; in other words, the two atomic "spheres" overlap.

L. H. W.

1838. *Atomic Weight of Isohelium.* **M. C. Neuburger.** (Phys. Zeits. 23. pp. 145–146, April 1, 1922.)—On the basis of Rutherford's experimental and theoretical observations on nuclear structure and the possibility of the existence of an element of atomic weight 3, the author now derives what he considers an accurate estimate of its atomic weight. The element is referred to as "isohelium" and its atomic weight given as 3·0011, the mass of the atom being $4 \cdot 95 \times 10^{-24}$ gm. A. B. W.

1839. *Precision Measurement of Crystals.* **W. P. Davey.** (Phys. Rev. 19. p. 538, May, 1922.—Abstract.)—By simultaneously recording the X-ray diffraction pattern of NaCl on one half of a film, and the pattern of some other crystal on the other half of the same film, it is possible to determine the dimensions of the second crystal in terms of the dimensions assumed for NaCl. On any one film the results so obtained are consistent among themselves. This may be shown by plotting the results on "probability paper." Values of crystal dimensions obtained from different films at different times agree to within one-tenth of one per cent.

By this method the side of the body-centred cube of CsBr is found to be 4·287 Å. The side of the simple cube (NaCl structure) of RbI is 3·654 Å. AUTHOR.

1840. *Crystal Structure of Quartz.* **M. L. Huggins.** (Phys. Rev. 19. pp. 363–368, April, 1922.)—*Structure of Quartz* (SiO_2).—By means of the Lewis theory, a structure has been obtained for quartz which accounts in a satisfactory way for the crystalline form, crystal symmetry, optical rotation, hardness, high melting-point, insolubility, and X-ray spectra of the substance. It is in strict accord with the conclusions of W. H. Bragg in regard to the structure.

Arrangement of Atoms and Electrons.—Each Si atom is surrounded by 4 pairs of electrons at tetrahedron corners, which act as bonds connecting it to 4 equidistant oxygen atoms. Each oxygen atom is also surrounded by 4 tetrahedrally oriented electron pairs, two of which serve as bonds connecting the oxygen to silicon atoms. *The crystal is thus not made up of SiO_2 units, but is a single molecule.* AUTHOR.

1841. *Crystal Growth.* **M. Volmer.** (Zeits. f. Physik, 9. 3. pp. 193–196, 1922.)—If crystals grew simply because arriving particles adhere to the spot in the lattice which they strike, the growth of some crystals could not be as much as 1000 times more rapid in one direction than in the other. There are two possibilities: either the molecules, like wedges,

penetrate into the surface they hit, or they are adsorbed at the surface and migrate off. The former view would require a continuous reorientation of the growing crystal and cannot explain why crystals evaporated in a vacuum become pitted and other difficulties. Further arguments are advanced in favour of the second view, though it likewise involves a certain reorientation. [See Abs. 1341 (1922).] H. B.

1842. *Crystal Structures of Alkali Halides.* **E. Posnjak** and **R. W. G. Wyckoff.** (Washington Acad. Sci., J. 12. pp. 248–251, May 19, 1922.)—The authors have determined the crystal structures of the alkali halides of lithium and of the fluorides of the alkali metals by a method previously described. For details of the observed data the original paper should be consulted. A. B. W.

1843. *Crystal Structures of Aragonite ($CaCo_3$) and Related Minerals.* **M. L. Huggins.** (Phys. Rev. 19. pp. 354–362, April, 1922.)

1844. *Line Entities and Line Domains.* **F. H. Loring.** (Chem. News, 123. pp. 329–331, Dec. 23, 1921, and 124. pp. 4–6, Jan. 6, 1922.)—In this speculative paper the author suggests that by analogy with atomic domains, involving forces which are best expressed as electric line fields, there may also be line domains. L. H. W.

1845. *Absolute Sizes of Certain Monovalent and Divalent Ions.* **W. P. Davey.** (Phys. Rev. 19. pp. 248–251, March, 1922.)—Further data are given [see Abs. 772 (1922)], the ions concerned being those of the elements oxygen, sulphur, Cu, Ag, Tl, Mg, Ca, Sr, Ba, Zn, Cd, Ni, Su, Pb. L. H. W.

1846. *Crystal Structure and Atomic Constitution.* **P. Niggli.** (Zeits. Kryst. Min. 56. pp. 12–45 and 167–190, 1921.)—Discusses the bearing of crystal structure on atomic constitution in the light of present-day crystallographic knowledge. L. H. W.

1847. *Disruption of Atoms.* **H. Elbertzhagen.** (Zeits. Elektrochem. 28. pp. 118–119, March 1, 1922.)—Taking up a suggestion of Soddy's, the author proposes to pass the spark discharge at high potentials through strongly-compressed gases or metal vapours (mercury) of high atomic weight and to insulate the transformers used with the same gases. H. B.

1848. *Relation between the Combined Atomic Volumes and their Optical Refractivities.* **G. Le Bas.** (Nature, 108. pp. 272–274, Oct. 27, 1921.)

1849. *Correlation between Wind Velocities at the Surface and those in the Free Air.* **L. T. Samuels.** (Monthly Weather Rev. 50. pp. 83–89, Feb., 1922.)—Correlation coefficients between wind velocities at the surface and those at various heights up to 3000 m. have been computed from kite records after first classifying the data by surface wind direction. In all cases where the correlation coefficient showed a significant value of 0·50 or more, with a relatively small probable error, the regression coefficients were determined for computing the velocities aloft from those at the surface.

The residuals for each group (i.e. each surface direction for which a correlation coefficient of 0·50 or more was obtained), when the observed velocities were subtracted from the computed, were found to be practically identically distributed and were therefore regarded as homogeneous. In view of this, they were all grouped together and a frequency polygon drawn. This exhibited a slight skewness and therefore the normal curve of error was not strictly applicable. A smooth curve was fitted by inspection. The arithmetic mean (disregarding signs) of the residuals was found to be 2·8; the median, zero class; and the mode, + 2 class. AUTHOR.

1850. *Volcanic Mud Flows.* **B. G. Escher.** (K. Akad. Amsterdam, Proc. 24. 6 and 7. pp. 282–292, 1922.)—Griggs explained a hot mud flow from Mt. Katmai, Alaska, June 1912, as due to the eruption from a fracture, of a quantity of water and mud. He was unable to account for it on any known grounds owing to the quantity of water involved. Similar phenomena, however, accompany the eruptions of the Klut volcano in Java. The sequence of events is as follows. During a period of quiescence the crater lake fills with water, and the first explosion erupts a mixture of pumice, ash, and water which makes up a hot mud flow, locally called a "lahar." This is followed by ejection of ash of the normal character. Succeeding heavy rainfall may cause another mud flow, this time a cold "lahar." This is very nearly the sequence observed at Mt. Katmai, and calculations of the amount of material ejected also bear support to the view that the Katmai flows were due to the same causes as at Klut. It is remarkable how much heat remains in the "lahar" after the water has in part drained away and in part evaporated. In March 1921 the temperature at a depth of 50 cm. in the flow of May 1919 was 178° C. W. A. R.

1851. *The Weight of Mountains: Gravity Deficiency in Switzerland.* **A. Heim.** (Schweiz. Bauzeit. 79. p. 66, Feb. 4, 1922. Engineering, 113. p. 563, May 5, 1922.)—Observations taken at 231 stations by Messerschmidt and Niethammer in the years 1908 to 1918 show that gravity is deficient throughout Switzerland except in the Brissago district. The deficiency increases as the level rises from the plains in the north-west of the country to the high Alps, and decreases again on the southern slopes, especially in the canton of Tessin. The author suggests that heavy mountains tend to sink, and that the level of the Alps may once have risen to 50 km., whilst the present max. height is 5 km. The anomalies are greatest in parts where the folding extends to the greatest depths. In view of these anomalies the sea-level datum seems to be the safest considering that nearly seven-tenths of the earth is covered by water. H. B.

1852. *Major Earth Movement.* **W. F. Jones.** (Am. J. Sci. 3. pp. 393–413, June, 1922.)—The facts of vulcanism and those deduced from seismic phenomena are considered as directly opposed to Chamberlin's postulated heterogeneity, laterally and in depth. Major earth movements can be readily accounted for by adjustments of an outer, somewhat rigid, shell on an inner yielding zone. W. A. R.

1853. *Notes from the Relativity Standpoint on the Kepler Ellipses.* **G. Jaffé.** (Ann. d. Physik, 67. 3. pp. 212–226, May 17, 1922.)—Lenard

has recently raised the question of the validity of the mode of calculation of the electronic orbits in the atom as based on the special theory of relativity. This was answered by v. Laue, who showed that according to the formula derived on the basis of the general theory of relativity for the gravitational field of an electric point charge, with consideration of the numerical relationships in the atom, no differences are to be expected between this result and that obtained from the special theory of relativity. The present paper deals with an extension of this problem, and investigates the exact conditions on which the Sommerfeld hypothesis is based, since the latter applied to the planetary problem affords a value for the perihelion motion of Mercury which is too small. The motion of a body of small mass and small electric charge in the field of a large mass with a high charge is examined. The equations of motion are derived on the basis of the general theory of relativity, and the differential equation of the orbit obtained and treated in three special cases. If the terms which determine the deviations from Euclidean metric are small against $(v/c)^2$, and the electric attraction large against the gravitational effects, then the equations become those of the Sommerfeld hypothesis. The above assumptions are fulfilled with extraordinary accuracy for the motion of electrons in the atom. In the application to the planetary problem only the first condition arises, and this is not fulfilled. With approximately circular orbits, ellipses with perihelion motion arise, depending on three conditions, namely: mass gravitation (Einstein formula), attraction of charges (Sommerfeld formula), and the gravitational effect of the central charge. If the charges be neglected and the deviations of the first order fully considered, then in addition to the Einstein perihelion motion occurs a form-change superposed over the ellipse as a wave with four nodes which only disappears at a small eccentricity. H. H. Ho.

1854. *Ionisation in the Solar Atmosphere.* **H. N. Russell.** (Mt. Wilson Observat. Contrib. No. 236. Astrophys. J. 55. pp. 354–359, May, 1922.)—The absorption of photospheric radiation by atoms in the sun's atmosphere tends to increase the degree of ionisation, both directly, by shifting an electron into a position from which its removal is easier, and indirectly, when enhanced lines are absorbed, by getting the ionised atoms into states in which they are probably less likely to combine with electrons. Both these influences operate strongly in the case of barium and weakly, if at all, for sodium. This probably explains why barium is much more highly ionised in the sun than sodium, although their ionisation potentials are the same. The case of lithium, which is also ionised to an abnormally high degree, cannot be explained in this way. The greater width of the lines, due to the thermal agitation of so light an atom, may help to solve the problem.

Barium.—The lines of this element which are present, or doubtful, in the solar spectrum are tabulated. All the strong lines arise from the ionised atom. A few faint lines of the neutral atom are probably present.

Rubidium.—Three enhanced lines of this metal are present, though faint, in the normal solar spectrum.

Manganese.—The ionisation potential 7·6 volts agrees well with the value predicted from the behaviour of its lines in the solar spectrum.

AUTHOR.

1855. *Distances of the Planets from the Sun.* **M. Pierucci.** (N. Cimento, 23. pp. 227–231, Feb.–March–April, 1922.)—In three preceding notes the author gave an empirical rule for the distances of the planets from the sun and showed that the rule holds good also for the distances from the relative centre of attraction of the satellites of Mars, Jupiter, and Uranus, of the ring and the five interior satellites of Saturn. For the planets the mean relative error is 4·80 %, while for the satellites of Mars it is barely 0·26 % and for the exterior satellites of Jupiter 1·14 %. It now appears to be a tenable hypothesis that the deviations from the rule are due : (1) to the eccentricity of the orbits ; (2) to perturbations in the formation of the orbit caused by the masses of the satellites and of the proximate planets. The present note is devoted to studying the first cause of error. Taking the satellites first and leaving aside the satellites of Mars, the interior satellites of Jupiter, the five interior satellites of Saturn and those of Uranus, for which no appreciable correction need be made, there remain only the four exterior satellites of Jupiter. Applying to them the principle of the " equivalent radius " referred to in a previous note, we find that they almost rigorously satisfy the rule : " the equivalent radii of the satellites are to each other as the whole numbers," the mean error being reduced from 1·14 % to 0·15 %. Applying the same principle to the planets the mean error is reduced from 4·80 % to 4·58 %. E. F.

1856. *Distances of the Planets from the Sun.* **M. Pierucci.** (N. Cimento, 23. pp. 233–238, Feb.–March–April, 1922.)—The empirical rule enunciated in four preceding notes [see preceding Abs.] is here extended to some cases in which it has hitherto not appeared to hold good, namely to the two exterior satellites of Saturn and to some comets. Somewhat amplifying the rule in the case of the satellites, that is to say considering, instead of the equivalent radii, their projection on the equatorial plane of the central body, the mean relative error is found to be 3·25 %. The five comets of which the equivalent radius was found to approximate to that of Saturn also satisfy the rule. The equivalent radii of the five comets are as the numbers 23, 25, 26, 27, 29, and the distance of which they are multiples coincides exactly with that of which the equivalent radii of the interior planets are multiples, that is to say, 0·362. There is close agreement between calculated and observed values, and it is further noteworthy that the figure 0·362 is identical to the third decimal for these five comets and for the four interior planets. In conclusion the author refers to the article by E. Dittrich (Astron. Nachr. 214. No. 5113, June 1, 1921) in which a new empirical rule is given for the distances of the planets and satellites from their centre of attraction, and he finds that Dittrich's rule gives a mean error of 16·3 %, whereas his own gives 11·9 %. E. F.

1857. *A Comparison between the Comets of which the Period is known.* **M. Pierucci.** (N. Cimento, 21. pp. 259–262, April–May–June, 1921.)—In order to compare the 25 comets of which the return has been observed, the author has calculated the area described by them in their path round the sun. If a and b are the semi-axes of the ellipse, its area is measured by πab. If now we consider circles equivalent to these areas, their radii will be $\rho_m = \sqrt{(ab)}$, which for brevity we may call equivalent radii. Arranging the various comets in the ascending order

of the equivalent radius we find that the first 20 have equivalent radii comprised between the mean distances of the asteroids from the sun, and taking the average we get the value 3·05, which is very near to the mean distance of the central zone of the asteroids themselves from the sun. The other five comets have equivalent radii very near to the equivalent radius of Saturn, from which the mean of the five radii differs only by 1·36 %. Therefore the comets of which the elements are known have equivalent radii comparable either with those of the asteroids or of Saturn. Is this a mere coincidence or does it point to a common origin of the short-period comets and of the asteroids, on the one hand, and of the mean period comets and of Saturn on the other ? It is already thought that some comets may originate from asteroids. That others originate from Saturn does not seem an unreasonable hypothesis, given the almost nebulous state of that planet. E. F.

1858. *Motion of Wolf's Comet.* **M. Kamensky.** (Am. de l'Obs. Astron. de Tokyo, 5. No. 5 [65 pp.], 1922).—This is a continuation of previous work on this comet [see Abs. 1925 (1908)] and has been held up on account of the war and the Russian revolution. Part IV deals with perturbations produced by the Earth, Mars, Jupiter, and Saturn, from 1884 Sept. 24 to 1891 July 10. Part V with those from 1911 March 28 to 1912 Feb. 11, and Part VI with those from 1912 Feb. 12 to 1918 Jan. 10. Further work is promised dealing with later periods. Discordance between theory and observation, on the basis of A. Thraen's figures (Akad. wiss. Wien, Ber. 64), the author attributes to incorrect elements and possibly inaccurate calculations, and he considers that his revision of these brings the observations into closer accord. He thinks, however, that it will be necessary to take into account perturbations due to Venus ; but his enforced exile from Bolshevist Russia will cause considerable delay, though he is finding grateful support in Japan which has enabled the present stages to be published after four years' delay. W. W. B.

1859. *Rôle of the Nebulous Medium in the Dynamics of Stellar and Planetary Systems.* **E. Belot.** (Comptes Rendus, 174. pp. 1056–1059, April 18, 1922.)—Following out the idea of stars penetrating nebulous masses [see Abs. 507 (1922)], the author considers the nebula to consist mainly of very light gases (H, He, etc.), holding in suspension solid or liquid particles of varying density. These dust particles will tend to condense on the irrupting star in order of decreasing density, the very light particles being repulsed by radiation. Stars differ much more in density than in mass, so that to penetrate to a given distance a giant star having great volume and low density will take longer and lose more velocity in the passage than a dwarf of equal mass but small volume and greater density. The giants will also tend to increase their mass, as more of the nebular dust will condense on them, while the dwarfs in their quicker passage will only pick up the densest particles ; they may even increase their density. Thus the nebulous masses will tend to be deprived of their heavier constituents. Moreover the penetrating stars will undergo a modification of type as well as alteration of velocity, since the most advanced (densest) classes are the swiftest. In the case of the solar system, planets will not be much slowed down by the

medium. It is usually claimed that a resisting medium will diminish the major axis of an orbit, but the author thinks that as the planets are not really points, but rotating and radiating masses, the real tendency is rather to increase the size of the orbit. He explains that Mercury, for instance, must be moving in a medium of very low density, and that a planet will not only pick up nebulous matter, but will in so doing diminish the density of the medium in its wake. He thus explains why the innermost satellites of Mars and Jupiter, Phobos and Jv, are able to continue in apparent stability. Similarly he disposes of Newton's objection to the Cartesian "vortices." This objection, that the vortices follow a law $T = a^2$, in conflict with Kepler's third law $T = a^{3/2}$, falls to the ground because the law $T = a^2$ can only hold in a vacuum; and no real vortex could exist *in vacuo*. Bringing in the medium results in centrifugal spirals in gravitational equilibrium which after condensation become planets obeying Kepler's law. W. W. B.

1860. *Theory of the Arrangement and Motion of the Sidereal System.* **J. C. Kapteyn.** (Mt. Wilson Observat. Contrib. No. 230. Astrophys. J. 55. pp. 302–328, May, 1922.)—*First Attempt at a Theory of the Distribution of Masses, Forces, and Velocities in the Stellar System.*—(1) *Distribution of Stars.*—Observations are fairly well represented, at least up to galactic lat. 70°, if we *assume that the equidensity surfaces are similar ellipsoids of revolution*, with axial ratio 5·1, and this enables us to compute quite readily (2) *the gravitational acceleration at various points due to such a system*, by summing up the effects of each of ten ellipsoidal shells, in terms of the acceleration due to the average star at a distance of a parsec. The *total number of stars* is taken as $47{\cdot}4 \times 10^9$. (3) *Random and Rotational Velocities.*—The nature of the equidensity surfaces is such that the stellar system cannot be in a steady state unless there is a general rotational motion around the galactic polar axis, in addition to a random motion analogous to the thermal agitation of a gas. In the neighbourhood of the axis, however, there is no rotation, and the behaviour is assumed to be like that of a gas at uniform temperature, but with a gravitational acceleration ($G\eta$) decreasing with the distance ρ. Therefore the density Δ is assumed to obey the barometric law: $G\eta = -\bar{u}^2(\delta\Delta/\delta\rho)/\Delta$; and taking the mean random velocity $\bar{u}$ as 10·3 km./sec., the author finds that (4) *the mean mass of the stars* decreases from 2·2 (sun = 1) for shell II to 1·4 for shell X (the outer shell), the average being close to 1·6, which is the value independently found for the average mass of both components of visual binaries. In the galactic plane the resultant acceleration—gravitational minus centrifugal—is again put equal to $-\bar{u}^2(\delta\Delta/\delta\rho)/\Delta$, $\bar{u}$ is taken to be constant and the average mass is assumed to decrease from shell to shell as in the direction of the pole. The angular velocities then come out such as to make the linear rotational velocities about constant and equal to 19·5 km./sec. beyond the third shell. If now we suppose that part of the stars are rotating one way and part the other, the relative velocity being 39 km./sec., we have a quantitative explanation of the phenomenon of star-streaming, where the relative velocity is also in the plane of the Milky Way and about 40 km./sec. It is incidentally suggested that when the theory is perfected it may be possible to determine *the amount of dark matter* from its gravitational effect. (5) The *chief defects of the theory* are then pointed out. AUTHOR.

1861. *Relation between Parallax, Proper Motion, and Apparent Magnitude.* **W. J. Luyten.** (Lick Observat., Bull. 10. [Circ. No. 336] pp. 135–140, 1922.)—Since Kapteyn derived his formula for the mean parallax of stars with given magnitude and proper motion, a large number of additional trigonometrical parallaxes have become available, and besides these the author wished to compare results from spectroscopic parallaxes, using the ordinary formula for absolute magnitude, $M_{abs.} = m + 5 \log \pi + 5$; where π is the parallax. He calls this M_π, differentiating between $M_{\pi tr.}$ and $M_{\pi sp.}$ according as the parallax is determined trigonometrically or spectroscopically. He finds also a corresponding function $M_\mu = m + 5 \log \mu + 5$, where μ is the proper motion. He thus obtains for each star whose parallax has been determined by both methods the four quantities, m $M_{\pi tr.}$, $M_{\pi sp.}$, and M_μ. Then dividing the stars into four groups according to spectral type, he has 192 F-stars, 253 G-stars, 232 K-stars, and 57 M-stars. These are arranged in order of magnitude of M_μ and divided into groups: ten for the F-, G-, and K-stars and six for the M-stars, the K- and M-stars being also subdivided into giants and dwarfs. These data he uses for solutions in two forms. $M^\pi = a + cM^\mu$ and $M^\pi = \alpha + \beta m + \gamma M_\mu$, the latter being essentially Kapteyn's formula. The diagram of results is given for F-, G-, and K-stars separately, the results being marked differently according to the method (tr. or sp.) used for the parallax. A table is subjoined giving the distribution in absolute magnitude and 26 spectral types of 4446 stars, the general range of magnitude being from − 6·0 m. to + 15·5 mag., and with isolated members extending from − 9·5 m. to + 20·0 mag. This is contrasted with the Mt. Wilson table of 767 stars. The author hopes to deal with the obvious discordances between these two tables in a subsequent paper. W. W. B.

1862. *Mean Parallax of Stars of Different Types.* **S. Hirayama.** (Ann. de l'Obs. Astron. de Tokyo, Appendix 10. [6 pp.] Jan., 1922.)—Spectroscopic parallaxes have recently been published for 1646 stars from Mt. Wilson [see Abs. 1029 (1921)], of these 799 have had trigonometrical parallaxes also determined. Excluding those with negative parallaxes, those with no determination of proper motion, and some whose computed parallaxes differ considerably from observed ones, there remain 664 stars of F-, G-, K-, and M-types. These are now divided into seven groups. F0–4, F5–9, G0–3, G4–9, K0–3, K4–9, and M, and mean parallaxes computed for each group. The smallest class, M, contains 50 stars and the largest, G4–9, 156 stars. The computed parallax is in the form $\log \pi = -A - 0{\cdot}05m + B \log \mu - C(\log \mu)^2$, m being the stellar magnitude and μ the annual proper motion. The value of A varies from 0·55 for class M to 0·88 for class G4–9; of B from 0·40 for class F0–4 to 0·80 for class M; C is small: 0·10 for class F0–4, smaller still for K and M, and zero for G and F5–9.

The author finds a fair agreement between the mean errors of the several computed and spectroscopic parallaxes, and hopes they will be useful until many more stellar parallaxes are known. W. W. B.

LIGHT.

1863. *Double Refraction by Regular Crystals.* **H. A. Lorentz.** (K. Akad. Amsterdam, Proc. 24. 6 and 7. pp. 333–339, 1922.)—In a review of the author's earlier investigations (1877–78) in the light of recent knowledge of molecular dimensions and of the facilities offered by the Röntgen rays for tracing out details of crystal structure, expressions are deduced in the case of rock salt leading to the expectation that under favourable circumstances a double refraction even in the visible spectrum should be detectable between crossed nicols. Experiments undertaken to observe this double refraction are described in which considerable difficulties are encountered arising from "accidental" double refraction due to inner structure deviations and tensions. The general conclusion is that the double refraction in question really exists. A. B. C. L.

1864. *Path of a Light-Ray in the Gravitation Field of One Body.* **W. van der Woüde.** (K. Akad. Amsterdam, Proc. 24. 4 and 5. pp. 187–191, 1922.)—The author starts with Droste's expression [Leiden Thesis, 1916] for Schwarzschild's line element $ds^2 = (1 - \mu/r)dt^2 - dr^2/(1 - \mu/r) - r^2(d\theta^2 + \sin\theta^2\, d\phi^2$ . . .(1), which by the substitution $r = \rho(1 + \mu/4\rho)^2$ becomes

$$ds^2 = \left\{1 - \mu/\rho(1 + \mu/4\rho)^2\right\}dt^2 - (1 + \mu/4\rho)^4\left\{d\rho^2 + \rho^2(\sin^2\theta d\phi^2 + d\theta^2)\right\},$$

where μ is the mass of the centre of gravitation C, and the space coordinates θ and ϕ have the values which would be ascribed to them by an observer believing the space to be Euclidean. Neither r nor ρ need be exactly equal to R, the distance measured from C on Euclidean suppositions, provided r and R or ρ and R are univalent functions of each other, since these, for not too small values of R, r^2/R^2 and ρ^2/R^2, may be taken as sensibly equal to unity. The units of length and time are assumed such that the light traverses unit length in unit time, so that 1 km. and $1/3 \times 10^5$ sec. may be taken as the units, and the mass μ is expressed in gravitation units. If the sun be the body, $\mu = 1{\cdot}47$, and μ/ρ will be very small even just outside the sun, so that, for a first approximation, the second and higher powers of μ/ρ may be neglected. Then, since for a line of propagation of light

$$ds = 0, \quad (1 - \mu/\rho)dt^2 = (1 + \mu/\rho)\left\{d\rho^2 + \rho^2\,(\sin^2\theta d\phi^2 + d\theta^2)\right\},$$

which reduces to $(1 - \mu/\rho)dt^2 = (1 + \mu/\rho)(d\rho^2 + \rho^2 d\phi^2)$, since the path will clearly lie in a plane through C, and we may put $\theta = \pi/2$. The author assumes that even now the path between two points A and B in 3-space may be found by making

$$\delta\int_A^B dt = \delta\int_A^B\left\{(1 + 2\mu/\rho)[1 + \rho^2(d\phi/d\rho)^2]\right\}^{1/2}d\rho = 0 \quad . . \quad (2)$$

Now analytically, if in space, now thought to be Euclidean, a planet of unit mass moves according to Newton's law in the gravitation field of the sun, the orbit is given by $\delta\int\left\{2(\mu/\rho + h)[1 + \rho^2(d\phi/d\rho)^2]\right\}^{1/2}d\rho = 0$, where h is the vis viva constant. Hence the solution of (2), $\phi = f(\rho)$, represents the orbit of a planet about the sun where $h = 1/2$, and

the converse is also true. The author takes each of these orbits, including the light-path in 3-space, as a conic section (which would be quite exact only if a conic section in a non-Euclidean plane were defined as a curve having the same polar equation as a conic, and this conflicts with the ordinary usage of differential geometry), but he argues that by means of equations $\phi = \phi_1$, $\rho = \rho_1$, it is represented in a Euclidean plane by a conic, where ρ_1 and ϕ_1 are polar coordinates, and he points out that these two equations represent the plane with the line element $ds^2 = (1 + \mu/\rho)(d\rho^2 + \rho^2 d\phi^2)$, *conformly* in the Euclidean plane, as the coefficients of the two fundamental forms are proportional. This being so, the author argues that no confusion will be caused by calling the curve $\phi = f(\rho)$ in the Einstein plane a conic, and claims that if in the image plane the tangent at B to the light-path AB makes with the radius vector CB a larger or a smaller angle than the straight line AB, it follows that not only, according to Einstein's theory, out of B the point A will be seen in a different direction from that expected from earlier theories, but also that the numerical value of the deviation may be read directly from the image. Now the paths of material points of unit mass moving according to Newton's law in the gravitation field of the sun, thought to be Euclidean, will all have the same value of h, and form a system of conics with C as common focus. And the semi-major axis of such a conic is known to be determined by $a = -\mu/h$, so that all the conics have equal major axes. Applying this to the present problem, it appears that the course of any light-ray is a hyperbola of which the sun is one of the foci, and the length of the semi-major axis is always equal to 2μ ($= \pm 3$ km.). The author goes on to show there are 8 such hyperbolæ, two of which only give a possible light-path, and both of these will actually be light-paths, if only the branch on which A and B lie does not intersect the sun. But it is easily seen that the last condition can be fulfilled by one hyperbola only. It is therefore impossible, from a point in the earth's path, to see any point in two different directions. G. W. DE T.

1865. *The Rendering Visible of Separate Submicrons to the Naked Eye.* **J. Traube** and **P. Klein.** (Phys. Zeits. 23. pp. 171–173, April 15, 1922.) —A description is given in the paper of the mode of rendering visible, in the Tyndall cone, to the naked eye, of ultramicroscopic particles of certain crystalline substances suspended in water. The cone was produced by means of a micro-arc lamp and a suitable slit, in a liquid contained in a glass vessel with plane parallel walls. The observations were made perpendicular to the light rays. The first experiments were conducted with lead carbonate prepared by adding 2 drops of $N/2$ sodium carbonate solution to 30 cm.^{2} of $N/30{,}000$ lead nitrate solution, the whole being well shaken. Gradually a feeble cone of lead carbonate developed, in which particles could be observed in rapid irregular motion. This motion is interspersed with a periodic flashing of different particles as a consequence of the rotatory component of the Brownian movement. The flashing phenomenon is explained by Siedentopf on the basis of diffraction. The particles, notwithstanding their minute dimensions, are still crystals. Several other substances were examined, *e.g.*, mercurous chloride, lead chloride, barium and calcium sulphates, calcium ammonium phosphate, calcium oxalate, vucin, and quinine, the results being tabulated. H. H. Ho.

1866. *Variation in Refractive Index near the Surfaces of Glass Melts.* **F. Twyman** and **A. J. Dalladay.** (Optical Soc., Trans. 23. 2. p. 131, 1921–1922.)

1867. *The Optical Three Apertures Problem.* **T. Smith.** (Optical Soc., Trans. 23. 2. pp. 132–140, 1921–1922.)—The submarine periscope is primarily considered; but the method employed is applicable to other instruments. L. H. W.

1868. *The Manufacture of Optical Glass.* **C. J. Peddle.** (Optical Soc., Trans. 23. 2. pp. 103–130, 1921–1922.)—(1) Historical. (2) Methods of manufacture. (3) The scientific aspect of manufacture. L. H. W.

1869. *Arc Spectra of Gallium and Indium, λ4511 to λ2170.* **H. S. Uhler** and **J. W. Tanch.** (Astrophys. J. 55. pp. 291–301, May, 1922.)—*To identify the lines*, spectrograms obtained with the pure elements and with various compounds and mixtures were compared; these were made with a short-focus concave grating spectrograph and with a large quartz prism spectrograph. *For the accurate determination of the wave-lengths*, spectrograms were made with a 21-ft. concave grating, special precautions being taken to minimise pole effects, to avoid mechanical displacements, and to obtain the lines sharp and separated from close lines of other elements. The wave-lengths for air, accurate in most cases to a few thousandths of an angstrom, and the vacuum wave-numbers are given for 23 gallium lines and for 34 indium lines. All the Ga lines and 28 of the In lines were found to belong to the *two subordinate series*, for each of which from 5 to 8 terms were identified. Preliminary values of the *constants of the Ritz-Paschen formula* for these series were calculated for both elements, but the agreement between observed and calculated wave-numbers is not satisfactory. The Mogendorff-Hicks formula was tested for gallium with even worse results. Four indium lines, previously supposed to be single, were resolved into from three to six components each.

Absorption spectrum of indium in a furnace.—Specially designed furnaces were used but only λλ4511 and 4102 were obtained. AUTHORS.

1870. *Quantum Theory of Band Spectra and its Application to the Determination of Temperature.* **R. T. Birge.** (Astrophys. J. 55. pp. 273–290, May, 1922.)—(1) *A summary of recent work* by Fortrat, Heurlinger, Kratzer, and others is given. It is now known that bands in the visible have the same structure as infra-red bands, each starting from a line of zero intensity and increasing in intensity symmetrically in both directions to maxima, the separation of the lines in one branch meanwhile decreasing until it becomes zero and then negative, the branch reaching a head. It is shown that Kemble's formula, $m^2_{max.} = 0{\cdot}699T/\Delta\nu_0$, for the number of the line of maximum intensity, $m_{max.}$, as a function of absolute temperature and limiting separation of successive lines for $m = +1$, a formula based on the statistical distribution of angular velocity given by the quantum theory, may be expected to give fairly accurate values of T though it neglects some factors. (2) *Evidence* is presented to show *that Kemble's formula holds* not only for infra-red bands but also for the CN band λ3883.

Cyanogen band λ3883.—(1) *Position of Max. Intensity as Function of Temperature.*—From a study of spectrograms made by Strutt and Fowler

and by King, $m_{max.}$ is found to vary from 9 ± 2 for light from a discharge tube containing active nitrogen at about 100° C., to 23 ± 2 for light from a furnace at 2500° to 2700° C., while the values corresponding to these temperatures as computed from Kemble's formula are 8·4, 22·9, and 23·7 respectively. This agreement justifies us in using the formula to determine the approximate temperature in the case of arcs, the sun, and similar sources which emit or absorb these bands. (2) *The intensity distribution in the A series from a* 13-*amp. arc* is symmetrical and corresponds to the empirical formula $\log I = 1{\cdot}5 \log m - c_2 m^{1{\cdot}5} + \text{const.}$ (3) *The relative intensity of the A, B, C, and D series* seems to be *independent of the temperature.*

Spectroscopic Determination of Temperature, Using CN Bands.—From the position of max. intensity on spectrograms made by the author, the *temperature of a* 13-*amp. arc* was computed to be 4500° C. ± 300, while from King's spectrograms *the temperature of a* 4-*amp. arc* comes out 3900° C. ± 300. By comparing solar spectrograms taken by St. John with the arc spectrograms the *temperature of the reversing layer of the sun* comes out 4000° C. ± 500. AUTHORS.

1871. *A Continuous Spectrum from Mercury Vapour.* **C. D. Child.** (Astrophys. J. 55. pp. 329–344, May, 1922.)—(1) *Conditions for Emission in Discharge Tube.*—A continuous spectrum identical with the fluorescence spectrum is emitted in addition to the ordinary line spectrum only when (*a*) the temperature of the vapour is above 120° C. and below 300° to 400°, depending on the pressure, when (*b*) the pressure is above 1 mm., when (*c*) the current-density is low, of the order of 10^{-4} amp./cm.^{2} or less, and (*d*) when very little air or other contaminating gas is present. An influence machine or transformer is better as a source of current than an induction coil, especially one with condensers. Ionisation of the vapour is not necessary for the emission of this spectrum since it was obtained with only 7 volts between the Wehnelt kathode and surrounding cylinder. (2) *In explanation* it is suggested that *the carriers of the spectrum* are molecules consisting of two or more atoms, which emit the fluorescence spectrum as a result of excitation by ultra-violet radiation $\lambda 2536$ emitted by atoms struck by electrons with energies corresponding to 4·9 volts or more.

Continuous Spectrum of Sodium.—Preliminary observations on heated sodium vapour in a discharge tube indicated that a continuous spectrum was present but much fainter than the line spectrum.

Ionisation Potential for Mercury.—Some observations on the current from a heated filament to a concentric electrode as a function of voltage seem to show that the ionisation potential *varies with the temperature*, reaching a minimum for about 140°, when it was 3 volts less than for 50°.

Change in Chemical Behaviour of Mercury Vapour at about 120° *C.*—Above 120° the vapour *reacts with air* to form a dark compound, but not below. This reaction is associated with the appearance of the continuous spectrum. AUTHOR.

1872. *Report on Series in Line Spectra.* **A. Fowler.** (Observatory, 45. pp. 145–147, May, 1922.—Review.)—The above-mentioned report has been published by the Physical Society of London (Fleetway Press, Ltd.).

1873. *Luminescence of Incandescent Solids (Oxides).* **E. L. Nichols** and **H. L. Howes.** (Phys. Rev. 19. pp. 300–318, April, 1922.)—Some oxides, when heated to a temperature lying within a definite and sometimes narrow range, emit radiation in a limited region of the spectrum far in excess of the radiation emitted in that region by a black body at the same temperature. The excess is ascribed to luminescence. As a striking example, the blue radiation from niobium oxide at 560° C. is about 85,000 times the corresponding radiation from a black body, the ratio decreasing with increasing temperature until it is 1·35 at 1037° C. just before the oxide melts.

The oxides of beryllium, magnesium, calcium, aluminium, silicon, and zirconium also show a blue glow, relatively strongest at the lowest stage of incandescence, decreasing to a minimum, then increasing to one or two crests corresponding to outbursts of blue luminescence between 1100° and 1500° C.

Intensity–temperature curves for the red, green, and blue radiations from the oxides of samarium, gadolinium, gallium, niobium, erbium, cerium, praseodymium, and neodymium, from 700° to 1550°, show that all except cerium emit a blue or green-blue glow, and all but niobium and neodymium have one or two red, green, and blue outbursts above 1000° C.

Luminescent emission bands of neodymium oxide occur approximately at *wave-lengths* 525, 550, 570, 615, and 660 $\mu\mu$. At 735° C. these bands were brighter than corresponding black-body radiation, but their excess *intensity* decreased, relatively, with increasing temperature until at 1010° they had disappeared into the continuous background of thermal radiation.

L. H. W.

1874. *On the Problem of Polarised Fluorescent Light from Dyestuff Solutions.* **S. I. Wawilow** and **W. L. Lewschin.** (Phys. Zeits 23. pp. 173–176, April 15, 1922.)—The resonance theory of fluorescence initiated by Stokes and developed by Lommel is in contradiction with many phenomena connected with fluorescence. A fundamental fact in this connection is the isotropy of the fluorescent light established by v. Sohnke. The latter, however, carried out his measurements with a nicol as analyser, and could only establish the absence of polarisation of fluorescent light from certain dyestuff solutions with an accuracy of 16–20 %. Wood, however, discovered [see Abs. 470 (1911)] a partial polarisation of the fluorescent light from sodium, potassium, and iodine vapours, although no satisfactory explanation of this phenomena has yet been forthcoming. In the light of Wood's results the question again arises, whether the fluorescent light from dyestuff solutions is partly polarised, and recently Weigert [Abs. 554 (1922)] has claimed to have discovered polarisation of the fluorescent light from the majority of typical fluorescent aqueous dyestuff solutions, *e.g.*, fluorescein, eosin, rhodamine, erythrosine, rose Bengal. Weigert employed a Savart polariscope with glass plate compensator for his quantitative measurements, whose sensitiveness attains about 1–2 %. Weigert's results for the above dyestuffs are tabulated in this paper. The polarisation was found to decrease in alcoholic solutions, but is increased by addition of gelatine and lowering of temperature. Weigert concludes from his observations that, contrary to accepted views, completely depolarised fluorescent light is the exception and not the rule. The theoretical significance of this result and the practical consequences therefrom have led the present

authors to repeat Weigert's fundamental experiments, and full details of these are included. The results obtained are exactly opposite to those stated by Weigert, namely: typical fluorescent dyestuffs illuminated by means of polarised light emit a depolarised light which can be measured with an accuracy of 1–2 %. The Weigert results were found to be explicable on the colloidal character of his dyestuff solutions. H. H. Ho.

1875. *Absorption of X-Rays.* **K. A. Wingårdh.** (Zeits. f. Physik, 8. 6. pp. 363–376, 1922.)—Gives a detailed description of a series of absorption measurements with a large number of compound and elementary substances. From the experimental results are deduced the mass-absorption coefficients of 31 elements extending from hydrogen to lead. For detailed information the original paper should be consulted. The following table includes the more important results:—

Element.	Z.	$\frac{\mu A}{\rho} \times 10^{-8}$.	μ/ρ.
H	1	0·001 ?	—
C	6	0·008	0·667
N	7	0·015	1·072
O	8	0·016	1·000
Na	11	0·078	3·392
Mg	12	0·112	4·605
Al	13	0·143	5·276
P	15	0·257	8·281
S	16	0·276	8·827
Cl	17	0·415	11·70
K	19	0·634	16·21
Ca	20	0·808	20·17
Cr	24	1·559	29·98
Mn	25	1·908	34·74
Fe	26	2·062	36·93
Co	27	2·247	38·11
Ni	28	2·828	48·19
Cu	29	2·946	46·33
Zn	30	3·610	55·22
Br	35	5·373	67·22
Sr	38	8·260	94·28
Y	39	8·858	99·52
Zr	40	1·793	19·70
Mo	42	1·966	20·48
Ag	47	3·322	30·79
Cd	48	3·404	30·28
Sn	50	4·170	35·04
I	53	5·000	39·76
Ba	56	5·683	41·36
An	79	19·89	100·9
Pb	82	21·06	101·7

Plotting log ($\mu A/\rho$) against log Z two straight lines are obtained,

represented by the formulæ $\mu A/\rho = C.Z^{3\cdot75}$ (from carbon to yttrium), and $\mu A/\rho = C.Z^{3\cdot44}$ (from Zr to Pb). A. B. W.

1876. *N-Series in X-Ray Spectra.* **V. Dolejšek.** (Zeits. f. Physik, 10. 2. pp. 129–136, 1922. Nature, 109. p. 582, May 6, 1922.)—With the new X-ray spectroscopic outfit constructed by Siegbahn [Abs. 572 (1922)] the author has endeavoured to find a weaker group of lines in the X-ray region than those previously known as the M-group. Some lines which must probably be referred to the N-series have, as a result of this investigation, been found in the case of the elements uranium and thorium. Hitherto, the measured wave-lengths for these lines lie, for Ur, between 8·6 and 12·0 Å.U., and for Th, between 9·4 and 13·5 Å.U. The values calculated theoretically lie within these limits. A. B. W.

RADIO-ACTIVITY.

1877. *New Radio-active Element UV.* **O. Hahn.** (Phys. Zeits. 23. pp. 146–150, April 1, 1922.)—The author discusses the possible existence of a new radio-active substance, uranium V, claimed to have been discovered by Piccard and Stahel [Abs. 145 (1922)]. On experimental and theoretical grounds the author concludes that the new substance UV does not exist. A. B. W.

1878. *Protactinium Content of Pitchblende Residues. Branching Ratio of the Actinium Series.* **O. Hahn** and **L. Meitner.** (Zeits. f. Physik, 8. 3. pp. 202–204, 1922.)—In a previous publication relating to the origin of actinium, the authors have shown [see Abs. 582 (1920)] that the branching ratio of the actinium series from the uranium series is not 8 % as previously supposed, but only 3 %. Since then several papers have been published by other workers giving a value for this ratio of about 4 % Further work by the authors relating to the protactinium content of pitchblende residues has confirmed their previous opinion. A. B. W.

1879. *Radio-Activity.* **E. Rutherford.** (Engineering, 113. pp. 299–300, March 10; 331–332, March 17; 365–366, March 24; 386–387, March 31; 414–415, April 7, and pp. 464–466, April 14, 1922. Lectures delivered at the Royal Inst. Electrician, 88. pp. 411–413, April 7, and pp. 501–504, April 28, 1922.—Abstract.)

HEAT.

1880. *Methods and Apparatus Used in the Cryogenic Laboratory.* XVIII. *Improved Form of a Hydrogen-Vapour Cryostat for Temperatures between* $-217°$ *and* $-253°$. **H. K. Onnes** and **C. A. Crommelin.** (K. Akad. Amsterdam, Proc. 24. 8. pp. 1185–1191, 1922. Comm. No. 154c from the Phys. Lab., Leiden.)—A description and views are given of a new cryostat which has been constructed in the Leiden laboratory. In this apparatus, which is larger than the one formerly in use, the experimental space is kept at constant temperature by means of a current of gaseous hydrogen, the temperature of which is kept at a definite value by automatic regulation of an electric current through a heating wire. It is found possible to keep the temperature constant to 0·01 deg. for some hours. T. H. P.

1881. *Dilatation and Compressibility of Liquids at Low Temperatures.* III. **W. Seitz.** (Ann. d. Physik, 64. 7. pp. 661–670, April 19, 1921.)—Gives the theoretical deductions arrived at from consideration of the experimental results already reported [Abs. 789 (1917)]. L. H. W.

1882. *Specific Heats.* II. **M. Padoa.** (Soc. Chim. Ital., Gazzetta, 52. i. pp. 25–29, 1922.)—The views expressed in a former paper (Accad. Lincei, Atti, 29. ii. pp. 198–202, 1920) lead to the conclusion that the low specific heats of elements deviating markedly from Dulong and Petit's law are due to the high number of valencies used by the atoms to ensure the stability of the crystalline edifice and to the exceptional energy of the corresponding linkings. Thus, if it were possible to separate the atoms of the abnormal element to such an extent that, although participating in the formation of the crystalline network, such atoms were no longer able to exert mutually disturbing actions, their specific heats should increase to the values exhibited by the other elements. Such a condition should be attained in solid solutions of an element of abnormal specific heat in excess of another of normal specific heat. Experimental confirmation of these views is furnished by measurements of the specific heats of silicon-iron and sulphur-selenium mixtures. In the former case, the atomic heat of Si is 4·74–4·83 in alloys containing 95–50 % of Si, whilst the values for 33·6 (FeSi), 14 and 10 % of silicon are, respectively, 5·27, 6·04, and 6·42. Heating of the 10 % Si mixture at above 1000°, followed by rapid cooling, fails to alter the specific heat. In sulphur-selenium mixtures containing 4, 9, 28·77, 90·35 (rhombic), and 90·35 (monoclinic) % of sulphur, the values of the atomic heat of sulphur are respectively 7·03, 6·00, 5·87, 5·50, and 5·78. T. H. P.

1883. *Theory of the Specific Heat in the Vicinity of a Transition Point.* **E. Brody.** (Phys. Zeits. 23. pp. 197–199, May 15, 1922.)—Most thermodynamic systems are so constituted that variations about the equilibrium state make no contribution to the energy of the system. The probability ω of an energy variation ϵ, is a direct function of ϵ, so that the average value ϵ disappears, but a case arises, which is the subject of the present paper, where this average is not zero, namely: a system in the vicinity of a transition point, *e.g.*, a solid body just below its melting-point. The absence of a kinetic theory of fluids and of knowledge with

respect to the mechanism of fusion, prevents treatment of the case quantitatively from this standpoint, but the author finds a mode of approach via the Einstein conception of the reversal of the Boltzmann principle. The work of Wigand, Ladenburg and Minkowski, and Schrödinger is also referred to. The latter introduces a term in his formula for the specific heats of fatty bodies to express the anomalous rise of the specific heat before fusion, and the present author deduces this effect to be very prominent for fine-grained structures, so that the previous treatment of metals is very important in this respect. H. H. Ho.

1884. *Maintenance of the Adiabatic Condition in Calorimetry.* **F. Barry.** (Am. Chem. Soc., J. 44. pp. 899–937, May, 1922.)—An investigation is made of the conditions for obtaining the highest degree of accuracy in calorimetric determinations of slow processes. A discussion is given of the influence of design and dimensions of containing vessels, the thermometric errors, heat of stirring, and the rate of heat exchange with the surroundings as a function of the change of temperature during the adiabatic condition. Newton's law is found not to be strictly followed in that though conduction and radiation vary directly as the temperature difference, convection varies more rapidly. The discrepancy is greater for very small temperature differences and for small spacings between inner and outer vessels than for larger values. If the walls of the calorimeter and the air space are not dry, a source of error is found to arise from changes in the amount of water adsorbed on the surface.

A description is given of a type of calorimeter in which the temperature of the water of the outer container is regulated so as to be approximately equal to the inside calorimeter. An empirical rule is given for estimating the magnitude of conduction leakage. The apparatus enables an accurate measurement to be made of the gain or loss of ½ gm./cal. during 10 hrs. The conductivity of air calculated from the values obtained for the thermal leakage with this apparatus is found at 20° C. to have the value $5{\cdot}7 \times 10^{-5}$. J. N. P.

1885. *Behaviour of Saturated Vapours.* **R. Plank.** (Zeits. techn. Physik, 3. 1. pp. 1–7, and 3. 3. pp. 69–78, 1922.)—A long paper dealing with the thermodynamical equations for the latent heat and specific heat of saturated vapours, and the various empirical equations which have been given for calculating such heats, attention being chiefly directed to the values of these quantities in the neighbourhood of the critical point. A comparison between the values given by the empirical equations and the results of experimental researches for water, CO_2, SO_2, and ethyl ether is given in several tables.

In the first section of the paper the well-known thermodynamic equations are given, $\lambda = AT(v'' - v')dP/dT$, where v' refers to the liquid, and v'' to the gaseous state, $C = Td\phi/dT$, where ϕ is the entropy. The relation $C''_x - C'_x = d\lambda/dT - \lambda/T$ is obtained, where x is the fractional vapour content in 1 kg. of liquid-vapour mixture. Hence $c''_p - c'_p = d\lambda/dT - \lambda/T + (\lambda/v'' - v')\{(\partial v''/\partial T)_p - (\partial v'/\partial T)_p\}$. The limiting values at the critical point are $v' = v''(\partial P/\partial v)_T = 0$, $(\partial^2 P/\partial v^2)_T = 0$, $(\partial v/\partial T)_p = \infty$, $(\partial v/\partial P)_T = \infty$, $\lambda = 0$, $\rho = 0$, $\psi = 0$, $(\partial\lambda/\partial T) = -\infty$, $\partial\rho/\partial T = -\infty$, $\partial\psi/\partial T = -\infty$, $c_p = \infty$, $c'_x = \infty$, $c''_x = -\infty$. Here ρ = internal, and $\psi = AP(v'' - v')$ the external latent heat. Hence $\lambda = \rho + \psi$. The experimental laws of Mathias, van der Waals, S. Young, Dieterici, and Trouton are referred to.

The next section deals with the empirical expressions given by Regnault, Clausius, Griffiths, Mathias, Nernst, Mollier, and Thiesen for the latent heat. These are discussed, and their limitations pointed out. The results calculated from the formulæ of Mollier and the author are compared in the case of CO_2 and of water-vapour.

Empirical equations for the pressure are then given, Nernst's formula $\log P = \alpha_1 - \beta_1/T + \gamma_1 \log T - \delta_1 T$ being compared with the Dupre-Hertz-Rankine formula $\log P = \alpha - \beta/T - \gamma \log P$. As both these expressions agree well with experiment, it is probable that the logarithmic term $\gamma \log P$ is unimportant, and that an exact pressure formula can be obtained without it. Such an equation is deduced by the author, and has the form $\log P = \alpha_2 - \beta_2/T - \delta_2 T$. A comparison between the results by these three formulæ and the experimental values of Siemens for oxygen is given in a table.

Empirical equations of state are next dealt with, the equations of Nernst and K. Onnes being discussed. An equation to displace that of Onnes is deduced. The specific heats at the boundary curves in the neighbourhood of the critical point are fully discussed with the help of diagrams, and the values compared with experimental results of Regnault, Ramsay and Young, and Sutherland in the case of ether and SO_2. From the investigations of van der Waals and Onnes, positive values for c_x'' for SO_2 as stated by Mathias are probably wrong. An expression deduced by the author gives negative values. The paper contains several diagrams and tables [Errata: *Ibid.*, **3**. 3. p. **102**, **1922**]. T. B.

1886. *The Disturbance Calculation in the Service of the Quantum Theory.* I. *A Method of Calculation.* **P. S. Epstein.** (Zeits. f. Physik, 8. 4. pp. 211–228, 1922.)—The method now described by the author was worked out by him some years ago in an investigation of the helium atom. The main idea, however, was not novel, but had been employed much earlier by Delauney in the lunar theory. Application of it is now made in the quantum theory. Reference is also made to similar work by Burgers, Whittaker, Bohr, and Kramers. The latter has applied Bohr's results with great success to the explanation of the gradual increase of the Stark-effect with the electric field. The author claims his present communication not to be superfluous, notwithstanding previous work, since his process is especially suitable for use in the quantum theory, and provides a method of finding a series of limited periodic systems which gradually approach nearer to the actual motion. To every stage of approximation correspond two essentially different kinds of motion, which condition the mode of transition to the next stage. These are discussed, and special emphasis is laid by the author on the physical significance of the transformation. The method also permits the evaluation of a small constant parameter by which the disturbance function may be developed. For the quantelation of coordinates, the method becomes automatic, since the correct variables may be found by a successive series of approximation operations. For the special case of the undisturbed motion being periodic, the coordinates found agree exactly with those obtained by Bohr's process. Section 2 of the paper deals with the transformation theory of dynamics; section 3, with the Delaunay method; sections 4 and 5, with an extended theory of limited periodic motion; and section 6, with the introduction of angular coordinates. The paper is mathematical throughout. H. H. Ho.

SOUND.

1887. *Efficiency of Artificial Aids to Hearing.* **P. E. Sabine.** (Phys. Rev. 19. p. 262, March, 1922.)—By comparison with the duration of sound audible to normal ears, the sensitivity of the deaf observer was determined in terms of normal sensitivity. The ratio of sensitivities was found to be of the order of 10^5 in the middle register (range examined, 128–4096 double vibrations per sec.). The max. amplification produced by any of the trumpets tested was about $101 \cdot 3$, while that for the telephone (at its natural frequency) was $10^{2 \cdot 5}$ The instruments tested were therefore inadequate for the relief of cases of extreme deafness.

L. H. W.

1888. *Sensibility of the Ear to Small Differences in Intensity and Frequency.* **V. O. Knudsen.** (Phys. Rev. 19. p. 261, March, 1922.)—A telephone receiver energised by a current from a vacuum-tube oscillator is used as a source of sound for determining the sensibility of the ear to small differences of loudness and pitch. Tones varying in frequency from 30 d.v. to 20,000 d.v. (double vibrations) are produced by the oscillator used in these experiments. Some auxiliary experiments showed that the acoustical energy developed by the receiver diaphragm is a linear function of the electrical energy which actuates it. The electrical energy is therefore a convenient measure of the relative acoustical energy at any fixed frequency. Data that have been taken on a limited number of ears show that the sensibility of the ear to small differences in intensity measured by the ratio of the smallest perceptible increment in energy to the whole energy, $\Delta E/E$, is : (1) Dependent upon the intensity. The ratio $\Delta E/E$ decreases as the intensity increases. For a wide range of moderate and high intensities the sensibility is nearly constant. Its value for ordinary frequencies is roughly $0 \cdot 10$. (2) Nearly independent of the frequency between 100 d.v. and 4000 d.v (3) Nearly the same for all normal ears.

The sensibility of the ear to small differences in frequency measured by the ratio of the smallest perceptible increment to the whole, is : (1) Dependent upon the intensity. The law of variation with intensity closely resembles the law of variation of sensibility to small intensity differences. (2) Dependent upon the frequency. The sensibility ratio decreases from about $0 \cdot 01$ at 50 d.v. to about $0 \cdot 002$ at 1000 d.v. For higher frequencies the ratio increases. (3) Only approximately the same for different ears. AUTHOR.

1889. *Minimum Sound Energy for Audition for Tones of High Frequency.* **C. E. Lane.** (Phys. Rev. 19. pp. 492–497, May, 1922.)—Using the new tone generator developed by Hewlett as the source of sound, experiments were carried on at night and out of doors on a platform raised 5 m. above the ground and with the listening ear 150 cm. from the source. The amplitude of vibration of the diaphragm of the generator was calculated from the electrical input, and from it the corresponding sound intensity at the ear of the listener was computed, assuming the amplitude of the sound wave at the diaphragm the same as that of the diaphragm and correcting for the concentration of sound around the

axis of symmetry as experimentally determined. No correction for the effect of the listener's head, however, was made. *Sensitivity frequency curves* for eight normal ears, ages 19 to 35 years, are reproduced. The minimum audible intensity was found to remain practically constant at 7×10^{-8} erg per cm.^{2} for frequencies from 2000 to 14,000 $\sim$ per sec., but above 14,000 the sensitivity decreased more and more rapidly until at between 18,000 and 20,000 $\sim$, depending on the individual, an intensity of 0·1 erg per cm.^{2} was inaudible. *A variation with age* was observed, the upper frequency limit being considerably higher for children and lower for older persons than for normal young adults.

Distribution of Sound Intensity around a Hewlett Tone Generator for 2000 *to* 15,000 $\sim$ *per sec.* was determined roughly by studying the minimum amplitude for audition as a function of the angular position of the listener with reference to the axis of symmetry. The sound is largely concentrated in a cone of about 20°, the angle decreasing as the frequency increased, so that for 10,000 $\sim$, for instance, the intensity 150 cm. along the axis was fifty times as great as if the distribution had been spherical. AUTHOR.

1890. *Sensitivity of the Electrostatic Transmitter for Measuring Sound Intensities.* **E. C. Wente.** (Phys. Rev. 19. pp. 498–503, May, 1922.) —The instrument is the same in principle as that previously described [Abs. 1162 (1917)], but certain changes have been made. The sensitivity is now constant over a long period of time. By means of a piston-phone and a thermophone both the absolute sensitivity and phase lag were determined for frequencies of from 10 to 12,000 cycles. Eight transmitters similarly constructed give the same curves within 20 %. With a steel diaphragm 0·0051 cm. thick having a natural frequency of 7000 cycles, and with an air-gap of 0·0025 cm., the mean sensitivity is about 0·35 millivolt/dyne. (2) *Use with an Amplifier for Measurement of Sound Intensity.*—Combined with an amplifier of ordinary design the instrument has an over-all sensitivity which is practically uniform from 25 to 8000 cycles. It is therefore remarkably well adapted for the measurement of the intensities of complex tones and tones of changing pitch and for use with an oscillograph for recording sound waves. L. H. W.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1891. *Radiation-Pressure on Transparent Dielectrics.* **S. Ray.** (Phys. Rev. 19. pp. 467–469, May, 1922.)—*A suggested explanation of photophoresis*, that is the attraction or repulsion of microscopic particles by light as observed by Ehrenhaft and others. It has previously been shown that there are electric and magnetic forces acting on an illuminated transparent body in the direction of propagation of the light if the ether has an electric density (P*e*) and a magnetic density (P*m*) other than zero. When one dielectric is immersed in another, the difference between these radiation forces per unit volume acting on the two media, would give rise to a relative motion which may be either in the direction of the light or in the opposite direction.

A Quantum Relation in Maxwell's Electromagnetic Theory is obtained if we equate the radiation-pressure per unit area in terms of P*e* and P*m* to the pressure derived from the stresses assumed by Maxwell to exist in electric and magnetic tubes of force, namely, the ratio of the amplitude to the wave-length of light is a constant. AUTHOR.

1892. *Theory of the Passage of Electricity in Anisotropic Bodies.* **K. E. Müller.** (Ann. d. Physik, 67. 3. pp. 201–211, May 17, 1922.)—This paper, which is entirely mathematical, considers in section 1 the case of an unlimited conductor with (*a*) point electrodes, (*b*) linear electrodes. In section 2 conduction in plates for linear electrodes is examined. It appears that great difficulties arise even in the simplest cases with respect to the functions derived for the three conductivities. The examination of the various forms of electrodes and boundary conditions of conductors has shown that in place of scalars the analogous tensors occur. For the treatment of conduction in plates, the application of the complex theory of numbers is found to be no longer possible. H. H. Ho.

1893. *Path of a Rigid Electron Moving in a Magnetic Field.* **E. O. Hulburt.** (Phys. Rev. 19. pp. 329–332, April, 1922.)—Mathematical.

DISCHARGE AND OSCILLATIONS.

1894. *Magnetic Control of Thermionic Emission from a Wire by Current in the Wire; Magnetron.* **A. W. Hull.** (Phys. Rev. 19. pp. 533–534, May, 1922.)—Mathematical analysis of the motion of electrons from a straight wire to a concentric cylinder shows that the electrons will reach the cylinder if the ratio of potential difference to current in the wire is greater than a critical value, and will fail to reach it if the ratio is less than that value. For a tungsten filament of diameter *d* cm. at 2500° K., heated by direct current, the critical voltage is $E=5310d^3\left(\log_{10}\frac{R}{r_0}\right)^2$ volts, where R and r_0 are the radii of the cylinder and the wire respectively. This is negligible for a $\frac{1}{4}$-mm. (10-mil) filament, but is approximately 10,000 volts for a 5-mm. filament in a 10-cm. cylinder, and nearly 100,000 volts for a 1-cm. filament. L. H. W,

1895. *Low-voltage Arcs in Diatomic Gases; Effect of Dissociation in a Tungsten Furnace.* **O. S. Duffendack.** (Phys. Rev. 19. p. 533, May, 1922.)—*Meaning of an Arc.*—When the space charge surrounding an incandescent kathode is neutralised by positive ions, the arc strikes and a redistribution of electric intensity, giving a large drop in potential near the kathode, results. This enables an electron to ionise a molecule at its first impact, and so an arc can be maintained at the ionising potential, or lower if the molecules are already partially ionised.

Average Breaking Potentials in Hydrogen and Nitrogen.—In hydrogen and nitrogen the average potentials of the breaks of arcs between a filament and a plate were 16·35 and 16·16 volts, respectively, which are within the range of ionising potentials of the molecules reported for these substances. As Bohr's theory puts the ionising potential of the hydrogen atom at 13·52 volts and the radiating potential at 10·14 volts, it seemed that it should be possible to maintain the arc at these voltages if there were sufficient monatomic hydrogen present.

Arcs in Monatomic Hydrogen.—When a tungsten furnace was employed, giving from 27 to 90 % dissociation at 2000° to 2500° K., the arc was maintained to 14 volts and the curves for the thermionic currents show sharp discontinuities at about 10, 14, and 16·5 volts. AUTHOR.

1896. *Formation and Life of Metastable Helium.* **F. M. Kannenstine.** (Astrophys. J. 55. pp. 345–353, May, 1922.)—*Current–potential curves for alternating and intermittent arcs in pure helium* between a Wehnelt kathode and nickel anode were obtained by use of a Braun-tube oscillograph for pressures of from 0·06 to 2 mm. With alternating voltages, the striking potential for each half-cycle was 29 volts or more for frequencies of 200 or less, but for frequencies of 220 cycles and above, the current started at about 5 volts and soon reached a saturation value until about 25 volts caused a further increase. In all cases the breaking potential was about 5 volts. To form the intermittent arc, the voltage was periodically dropped from 36 to some lower predetermined value. If this lower potential was less than 4·6 volts, the arc was suddenly extinguished; if between 4·6 and 23·7 volts, the arc died out gradually; and if it was 25·3 volts or above, the arc was maintained. All the foregoing values include a correction of 1·1 volt added to the actual readings to bring them in agreement with accepted results.

Evidence as to the Life of Metastable Helium.—To explain various experimental results, it has been suggested that atoms of helium, partially ionised by electronic collisions of 20·8 volts or more and hence capable of complete ionisation by further impacts of 4·8 volts or more, remain in this metastable condition for an appreciable time. The foregoing results not only confirm this suggestion, but also show that under the circumstances of this experiment the metastable form persists for about 0·0024 sec. AUTHOR.

1897. *The Electrodeless Discharge in Certain Vapours.* **J. K. Robertson.** (Phys. Rev. 19. pp. 470–477, May, 1922.)—*Spectrum of Electrodeless Discharge in Various Vapours.*—The arrangement used was that of Abs. 1460 (1921). The effect was found to *vary with vapour pressure*, controlled by the temperature, *and with e.m.f.*, controlled by a spark gap. In general, for a certain range of pressure, an intense ring discharge was obtained which weakened to a faint luminosity for higher pressures.

Potassium at temperatures of 250–300° C. gave a bright ring with a spectrum including seven or more members of each subordinate series. The bright yellow discharge in *sodium* above 300° C. showed the D-lines, four members of the diffuse series, and three members of the sharp series. With *lithium* up to 500° C. only a feeble discharge due to impurities was obtained. In the case of *mercury*, the work of Kowalski was confirmed and extended. A dazzling white ring discharge appeared from 70 to 110° C. or higher depending on the spark-gap ; then became fainter, while a greenish glow whose spectrum showed a few lines superposed on a continuous band extending from the violet to the yellow, appeared for 110 to 115° C., *irrespective of the spark-gap*. In the case of *iodine*, the only diatomic vapour studied, at temperatures from — 5° to 5° C. a pale yellow ring showing a band spectrum changed to a green, pink-bordered ring with a line spectrum when the spark-gap was increased ; the higher the pressure, the greater the spark length necessary to excite the line spectrum.

Electrodeless discharge as a source of sharp lines should be of value in measuring wave-lengths and in analysing, with an instrument of high dispersion, lines with components due to isotopes. L. H. W.

1898. *Characteristics and Theory of the Sound Amplifier in Discharge Tubes with High Gas Pressure.* **E. Marx.** (Ann. d. Physik, 67. 2. pp. 77–126, April 27, 1922.)—The author's object is to allow the amplification ratio to be calculated from the characteristic with soft valves in a similar way to the analogous calculation for hard tubes, elaborated by various investigators. The problem for hard valves is simplified owing to this being a purely electronic phenomenon, whereas for soft valves a similar mathematical presentation is complicated by the ionisation effects. The present paper is highly mathematical, and does not permit of abstraction. After describing his apparatus, which utilised a 5-electrode valve (in which two electrodes served to produce kathode rays, one served to produce a high potential fall, and the remaining two were used as grids, one being an auxiliary controlling grid), the author deals with the following subjects :—Interpretation of the course of the characteristic upon the basis of ionic motion ; Application of the methods to the descending part of the characteristic ; Representation of the differential equations and integral of the terminal voltage of the control electrode, as simple functions of the a.c. constants of the circuit and the periodic variations of the applied alternating voltage ; Original conditions for the oscillatory potential when no potential is present other than the e.m.f. of the electrodes ; Determination of the terminal voltage of the control electrode which occurs by sudden application of a high voltage ; Determination of the constants of the integrals for the impressed oscillation ; General equation for the terminal voltage of the control electrode in terms of the parameter of the characteristic and the apparatus constants, with reference to the anode fall, potentiometer adjustment, and alternating current to be intensified ; The self-discharge of the descending characteristic and its sign ; Summary of the mechanism of voltage excitation of the control electrode by introduction of an alternating current to be amplified ; Principles for calculation of the amplification factor ; Formulation of the ratio of the mean oscillation amplitude with and without amplification ; The best telephone connections without amplification for a given microphone load, and comparison of the same ; Dependence and value of the

extreme amplitude upon the statical terminal voltage adjustment in units of the characteristic; General dependence of the amplification as a function of the statical terminal voltage; Limits of amplification of musical tones; Numerical satisfaction of the theoretical results; Numerical calculation of amplification ratio; Amplitude comparison by direct connections; Calculated and observed amplifications.

B. J. L.

1899. *Natural Oscillations of Systems of Circuits.* **L. Bouthillon.** (Rev. Gén. d'Él. 11. pp. 656–661, May 6, 1922.)—The author demonstrates in this article some theorems upon systems of n circuits, oscillating or not, provided or not provided with resistances. E. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1900. *Electrical Properties of "Illium" Resistance Wire.* **C. T. Knipp** and **J. L. Hall.** (Phys. Rev. 19. pp 283–284, March, 1922.)—Illium was first produced in wire form early during the summer of 1921, making possible the measurement of a number of the electrical properties of this chemically highly resistant alloy. The wire for these experiments was furnished by S. W. Parr, of the Department of Chemistry, University of Illinois. It was of the particular type known as "Illium-B." The resistivity, using the same sample on the basis of the resistances measured over the above range of temperature, was found to be, when extrapolated to 0° C., $91{\cdot}61 \times 10^{-6}$ ohm-cm. L. H. W.

1901. *Properties of Selenium.* **W. Späth.** (Zeits. f. Physik, 8. 3. pp. 165–183, 1922.)—A detailed investigation of the variation in the dielectric constant of selenium due to the incidence of light, and especially of its relation to the inertia and fatigue phenomena exhibited by the element. A slab of Se about 2-3 mm. thick was contained between a brass electrode and a semi-transparent electrode of Pt deposited upon a glass plate. The resistance of the cell was of the order 10^6 ohms and its capacity from 50-100 cm. The selenium was illuminated by the light from a Nernst filament, the intensity of illumination being measured by a superficial bolometer. The Se cell was inserted in a circuit in which oscillations were maintained by means of three-electrode valve. Any change of capacity of the cell due to its illumination was indicated by a change of deflection of an aperiodic galvanometer inserted in a circuit in which currents were induced by those produced in a second circuit coupled with and tuned to approximate resonance with the primary circuit. The author finds that the capacity and electrical conductivity of a selenium cell are related in much the same way to the intensity of illumination of the cell. The relation between the intensity of illumination and the proportional increase of capacity of the cell is approximately parabolic. A two- or three-fold increase of conductivity of the cell due to illumination corresponds, however, to an increase of only about 5 % in the capacity of the cell. The inertia effect on removal of the illumination is greater than that evidenced on illumination of the cell, both as regards conductivity and capacity, and is, moreover, smaller for soft cells. A fatigue phenomenon evidenced in the conductivity is accompanied by a similar effect as regards capacity. Fatigue, both as regards conductivity and capacity, is more clearly evidenced in soft cells than

in hard cells, provided the intensity of illumination employed is high. For low intensities of illumination, the fatigue curves for soft cells approximate to those characteristic of hard cells. An ionisation theory resembling that customarily employed in the discussion of radio-active transformations and gaseous conduction, is developed by the author and accounts satisfactorily for the observed phenomena. J. S. G. T.

1902. *Resistance and Thermoelectric Power of Metallic Germanium from* $-191°$ *to* $675°$ *C.* **C. C. Bidwell.** (Phys. Rev. 19. pp. 447–455, May, 1922.)—Measurements were made on a pure specimen of this rare metal in the form of a rod 2·4 by 0·44 by 0·41 cm., prepared under the direction of L. M. Dennis. The current was led in through graphite blocks and thermo-junctions were placed in grooves near each end. For the thermo-electric power determinations a temperature gradient was secured by placing the specimen in a non-uniform part of a furnace or refrigerator and also by using a heater coil wound on one end. Between 125° and 450° the results indicate a slow reversible transformation of some sort, for below and above this range the thermoelectric power is a linear function of the temperature and also, except in the range 100° to 600°, the resistance is an exponential function of the form $\log R = \log A + aT + Q/kT$. The resistivity reaches a minimum at $-116°$ and again at 645°; its value at 0° is 0·089 ohm-cm. The temperature coefficient changes from positive to negative with rising temperature.

Periodic relations among the elements with reference to temperature variation of resistance are pointed out. High-resistance elements toward the right side of the Periodic Table have characteristically negative coefficients, while the good conductors toward the left side have positive coefficients. The elements in Group IV (C, Si, Ti, Ge, and Zr) show transitional behaviour, each giving indications at least of a minimum resistance at temperatures which decrease regularly from very high for the lightest to very low for the heaviest element.

The transformation in Germanium, 125° *to* 450° *C.*, as indicated by the above data, shows no hysteresis, the rapid cooling curves duplicating the slow cooling and heating ones. The phases are always in equilibrium, one, perhaps, being dissolved in the other. AUTHOR.

1903. *Effect of Tension on the Change of Thermo-E.M.F.'s by Magnetisation.* **A. W. Smith.** (Phys. Rev. 19. pp. 285–299, April, 1922.)—*Combined Effect of Tension and Magnetic Field on Thermoelectric Force and Resistance of Ferromagnetic Metals.*—Wires 10 cm. long and 0·15 cm. in diameter were each held in heavy brass clamps and stretched while placed axially in a vertical solenoid. While determining the e.m.f.'s, one end was kept at 100°, the other at 0° C. In the case of *nickel*, the effect of tension on the change in resistance (ΔX) and in thermoelectromotive force (ΔE) produced by a longitudinal magnetic field is a decrease for weak fields but an increase for larger fields. For a given tension, the ratios of ΔX to ΔE and to the magnetic change of length (ΔL) are independent of the field strength and therefore seem to depend on the same factor. *Pure iron* shows a parallelism between the effects of tension on ΔE and ΔL; with increasing tension the curves for ΔE as function of the field shift downward, so that for sufficiently large tensions ΔE becomes negative throughout. The curve for ΔE may be considered the sum of two effects, associated with two forms of iron, one of which is proportional to ΔL

and is affected by tension more than the other. The behaviour of *iron-copper alloys* is qualitatively similar to that of iron. *Iron-nickel alloys* behave like iron until the percentage of Ni is more than 7 when they tend to behave more and more like Ni. For both series of alloys the change of ΔX due to tension is always a decrease.

The relation between Hall constant, specific resistance and change of thermoelectric force produced by a magnetic field in iron-copper alloys is pointed out. The three properties vary with copper content in a similar way, all showing a cusp for 1·5 per cent. Cu. L. H. W.

1904. *Thermoelectric Peculiarities of Quenched Iron; Z Transformations.* **G. Borelius** and **F. Gunneson.** I and II. (Ann. d. Physik, 67. 3. pp. 227–235, and 236–252, May 17, 1922.)—I. In trying to develop a new method of iron analysis, the authors heat specimens of the same iron to different temperatures, quench them in water, and determine the thermo e.m.f. against an untreated specimen; the temperatures of successive tests are so chosen that the whole range from 100° up to 1000° C. is covered. The work, first done on commercial iron and steel, showed peculiar irregularities in the curves when microvolts were plotted against temperatures.

II. Further experiments were made with pure electrolytic iron from Heraeus, which had been fused in a vacuum furnace, and other specimens. The curve of pure iron is free of fluctuations of more than 0·01 microvolt which would fall within the limits of error. When the iron was heated in hydrogen and in coal gas, the fluctuations became greater, amounting after 7 hours in coal gas at 800° up to 1 microvolt. Electrolytic iron hardly takes up gaseous hydrogen when being heated in the gas, but is probably not quite free of hydrogen even after heating to 850°. In iron fluctuations of 0·03 microvolt were observed, and the authors distinguish twelve such points of new Z transformations between 100 and 1000°. Similar, but not identical, Z points are obtained with specimens of other iron, but only when the iron has been quenched. The Z points may be related to the points at which heated iron gives off hydrogen; this evolution is not gradual and is accompanied by liberation of heat (Roberts-Austen; A. Müller and Maurer, 1909). The quenching is essential for the Z effect, which is therefore chiefly observed in carbon-iron (not in silicon-iron). The Z effect seems to be due to the presence of impurities in the iron, carbon, in the first instance, probably also hydrogen. As even electrolytic iron contains traces of carbon, it is difficult to discriminate between the two factors. H. B.

1905. *Dielectric Hysteresis and Allied Phenomena.* I. **H. Saegusa.** (Tôhoku Univ., Sci. Reports, 10. pp. 433–443, Jan., 1922. Paper read before the Math. Phys. Soc. Japan, April, 1921.)—In continuation of previous work [Abs. 1600 (1921)] the author has investigated the dielectric hysteresis and allied phenomena exhibited by thin plates of rock salt, black quartz, selenite, and microcline. In quartz, the limiting potential is more definite than in the other crystals, and the stationary hysteresis loop is readily distinguished from the plastic hysteresis loop. The time effect, residual charge, and hysteresis loop in black quartz are much greater than those characterising transparent quartz, and in the case of crystals of the monoclinic system are much smaller than those characterising crystals of the hexagonal and isometric systems. The limiting

potential of the former system is much larger than that of the latter system. The form of the hysteresis loop characterises the crystal and the direction in the crystal. Impurities greatly increase hysteresis effects and reduce the value of the limiting potential. J. S. G. T.

1906. *Quantum Theory of Dielectrics.* **H. Saegusa.** (Tôhoku Univ., Sci. Reports, 10. pp. 445–452, Jan., 1922.)—From the consideration of the oscillations of uniformly distributed molecular electric doublets, using Sommerfeld's quantum phase-integral condition, an expression, of a more general nature than that of Debye, is derived for the relation of dielectric constant to temperature. Experimental values of the respective dielectric constants of methyl and ethyl alcohols at various temperatures, confirm within the limit of experimental error the accuracy of the relation. [See also Abs. 571 (1912).] J. S. G. T.

1907. *Dielectric Constant of Mica.* **J. R. Weeks, Jr.** (Phys. Rev. 19. pp. 319–322, April, 1922.)—The constant was determined for 18 samples of mica, varying in thickness from 0·005 to 0·073 in. and including 12 different grades. Each sheet was placed between two mercury electrodes, and the capacity of the condenser thus formed was determined with a shielded capacity and conductance bridge using alternating current at 1000 cycles per sec. It was found that while thick sheets with plainly visible air films had low dielectric constants, those without such films gave fairly consistent results, running from 6·4 to 9·3 with an average of 8·1. When a thick sheet was split, the thinner sheets had higher constants except in the case of a sample of Canadian amber.

The power loss in mica condensers was too small to determine accurately with the apparatus used, but was higher for stained than for clear micas. AUTHOR.

1908. *Action of Hertzian Waves on Powders and Explosives.* **Briotet.** (Mem. des Poudres, 18. pp. 208–226, 1921.)—A powerful Hertzian field was obtained by means of a closed oscillatory circuit from an Oudin solenoid connected with a 10-cm. spark Ruhmkorff coil and condensers. No influence was detectable on the stability of powders exposed for prolonged intervals in proximity to the field. This result would be expected from the standpoint of the identity of electrical and luminous vibrations when of the same frequency. While the decomposing action of ultra-violet light is to be explained by its frequency being of the same order as that of molecular motion so that resonance effects can be set up which finally lead to demolition of the molecular structure, the electrical vibrations from Hertzian waves are of a much greater wave-length. Powders may, however, be ignited by sparks which may arise from charges induced by powerful oscillating fields in neighbouring masses of insulated metal.

It is found that exposure of powders to a powerful electrostatic field is also without appreciable influence on their stability. J. N. P.

1909. *Piezoelectric Activity of Rochelle Salt under Various Conditions.* **J. Valasek.** (Phys. Rev. 19. pp. 478–491, May, 1922.)—*The electrical properties of Rochelle salt crystal* are analogous to the magnetic properties of iron, the dielectric displacement D and polarisation P varying with

the electric field E in the same general manner as B and I vary with H for iron, and showing an *electric hysteresis* with loops distorted by an amount corresponding to the *permanent polarisation* P_0, whose value is about 30 e.s.u./cm.^{3} but varies for different crystals. The *dielectric constant* ($\kappa = dD/dE$) was measured *from* — 70° *to* 30° C. and found to be surprisingly large, increasing from about 50 at — 70° to a maximum of about 1000 near 0°. The modulus of *piezoelectric activity for shearing stresses* (δ) *varies with temperature*, — 70° *to* 40° C., in a very similar manner, increasing from less than 10^{-6} at — 70° to a maximum of about 10^{-4} at 0°. The ratio δ/κ *varied with the electrode material*, being greater for tin-foil than for mercury electrodes. The difference may be due to the alcohol used in shellacking the tin-foil electrodes on. There are other indications that δ and κ are related. The *variation of* δ *with humidity* is such as can be accounted for by the decrease in the dielectric constant of the outer layer as a result of dehydration. The change of polarisation produced by pressure as measured by the change in the hysteresis loop agrees with the value found directly from the piezoelectric response, as required by Kelvin's theory. Also *fatigue effects on* δ produced by temporarily applied fields are traceable to fatigue in the polarisation. The *electric conductivity below* 45° is less than 5×10^{-9} mho/cm.^{3} but *from* 43° *to* 57° increases rapidly to 5×10^{-4}.

Optical Properties of Rochelle Salt as Calculated from the Natural Polarisation.—Assuming only one electron is displaced the *natural period* corresponds to a wave-length of $4{\cdot}2\ \mu$ and the *specific rotation* for sodium light comes out 10°, the observed value being 22°·1. [See Abs. 1152 (1921).]

AUTHOR.

1910. *Mutual Inductance of Two Cylindrical Coils having Parallel Axes.* **E. Mathy.** (J. de Physique et le Radium, 3. pp. 178–180, May, 1922.)—Methods of computing the mutual inductance between two cylindrical coils having their axes parallel are given. They are based on the formulæ previously proved for the mutual inductance between two circles with their planes parallel [see Abs. 376 (1922)]. The solutions are given first in terms of elliptic functions, secondly in power series, and finally in hypergeometric series. A. R.

1911. *Simplified Method of Correcting for the Decrement of a Decremeter.* **R. R. Ramsey.** (Phys. Rev. 19. p. 274, March, 1922.)—The formula usually employed is hard to manipulate. The author proposes to obtain d, the decrement of the circuit to be measured, from the relation $d = RT/(2L)$. When $R_1 = R$, then $rd = (R_1 + R)T/(2L)$, where L and R are the inductance and the resistance in circuit. R_1 can be determined by the "half deflection" method of measuring resistance. The decrement D_1 is measured first in the usual way; resistance is then introduced until $R_1 = R$, and the decrement again measured, D_2. Then $D_2 = d + 2d$. Hence $d_1 = D_2 - D_1$. L. H. W.

1912. *Rectification Effect with Illuminated Zinc Blende Crystals.* **H. Zahn.** (Zeits. f. Physik, 8. 6. pp. 382–389, 1922.)—The work of Gudden and Pohl [Abs. 978 (1922)] on the photoelectric conductivity of crystals has shown that most probably the photoelectric current can be divided into two parts, a primary current independent of time and proportional to the incident light energy, and a secondary current which increases with the time and is of an electrolytic nature. By using small

field strengths and short exposures the secondary current I_s was rendered relatively small and the primary current I_p could be investigated. By the use of alternating currents the range of the investigation could be considerably extended, since I_s was thereby completely suppressed. The alternating-current method was employed in the research here described. The experiments showed that a crystal of zinc sulphide, to which an alternating electric field is applied, exhibits a rectification effect, and a direct current may thus be made to flow through a galvanometer shunted across a condenser in series with the crystal, choking coils in the galvanometer leads preventing the passage of alternating current. The rectification effect increased with the intensity of the incident light, and with the strength of the applied alternating field, but decreased with increased frequency. The effect was also found to depend on the colour of the light used. A. W.

1913. *Use of Detector and Galvanometer to Obtain Resonance Curves.* **F. van Aalst.** (Jahrb. d. drahtl. Tele. 19. pp. 139–142, Feb., 1922. Dissertation, Basle, 1921.)—The research described was undertaken with the object of investigating how far resonance curves, obtained for an oscillatory circuit by means of a detector and galvanometer, could be used for determining the damping. The possible sources of error are (1) the non-linear character of the detector characteristic, (2) the energy consumption by the detector and galvanometer, (3) the different behaviour of the detector for high-frequency alternating current and for direct current, and (4) the effect of the alternating-current resistance of the galvanometer on the detector. These points are briefly discussed. A. W.

1914. *The Electronic Valve as a Variable High Resistance.* **P. Lertes.** (Zeits. f. Physik, 4. 4. pp. 472–473, 1921.)

ALTERNATING CURRENTS AND MAGNETISM.

1915. *The Standardisation of Permanent Magnets.* **R. Hamer.** (Phys. Rev. 19. p. 551, May, 1922.—Abstract.)—For an investigation on the "ageing of so-called permanent magnets" used in wattmeters, signal devices, and electrical meters, it was necessary to devise an expeditious method which would yield results accurate to a hundredth of one per cent. instead of the usual several per cent. The author succeeded by adopting a null method. The total magnetic flux of a so-called permanent magnet was cut by a falling coil. The current generated was opposed by that from a coil simultaneously cutting the flux of a solenoid carrying an accurately adjusted current. Thus only the difference in flux caused the resultant current through the fluxmeter, and by calibrating the fluxmeter scale an exact balance was not necessary. Due precautions against thermal and magnetic interferences had to be taken. L. H. W.

1916. *Effect of Nascent Hydrogen on Hard-Steel Magnets.* **J. Coulson.** (Phys. Rev. 19. p. 528, May, 1922.—Abstract.)—Investigations having proved that steel absorbs hydrogen at ordinary temperatures, it was considered probable that the "ageing" of permanent magnets was due primarily to the action of slowly absorbed hydrogen. Bar magnets of "Special Alloy Magnet Steel" and high-carbon steels were exposed to the action of electrolytic hydrogen while serving as kathode in an

electrolyte of 25 % H_2SO_4. Results of observation are given in table and in curves showing the decrease in magnetic moment as a function of the time of exposure.

Well *seasoned* magnets of drill rod, quenched glass-hard, underwent a further decrease in moment of 14 % on exposure to the hydrogen. The moment of similar magnets of spring steel and special magnet steel experienced a precipitous drop in the course of the electrolytic treatment, which was not in evidence with magnets of drill rod. For magnets of spring steel this sudden drop occurred after 20 or 30 minutes' exposure, and amounted to about 5 %. For the special magnet-steel it occurred after a few minutes, and in some cases amounted to 19 %. Before and after this sudden transition the rate of change in moment was only a fraction of 1 %.

Exposing the magnets to the electrolytically evolved hydrogen in heated electrolyte accelerated this ageing process. At 60° C. the magnetic moment reached stability in an hour or less. Hammering the magnet at this stage had little or no effect on its moment. The effect usually is about one part in 1600. AUTHOR.

1917. *Magnetostriction with Small Magnetising Fields.* **J. R. Hobbie, Jr.** (Phys. Rev. 19. pp. 456–466, May, 1922.)—*Piezoelectric Method of Measuring Small Magnetostriction Effects.*—In this method, suggested by Pupin, the wire to be studied is surrounded by a solenoid through which an alternating current of known strength and frequency is sent, and the vibrations set up in the wire are transmitted to a piezoelectric crystal and the resulting electric charge is amplified and measured. (1) For elongations down to 2×10^{-9} the wire was hung directly from a *quartz crystal.* To measure the charge produced by a given magnetising current, an electromotive force of the same frequency and adjusted by means of a Pupin wave balance to the proper phase, was fed to the amplifier through a vacuum tube in parallel with the one connected to the crystal, and the potential was varied until the note produced by the crystal was balanced out. The force corresponding to a given charge was determined with the aid of a condenser, one plate of which was suspended from the crystal. (2) By using the torsion of a *Rochelle salt* crystal, the sensitiveness was extended to 2×10^{-11}, and (3) by tuning both the crystal and the wire to resonance with the frequency used, a sensitiveness of 3×10^{-12} was reached. The last two arrangements were calibrated in absolute units by comparison of the results with those obtained with quartz. The smallest change previously measured was about 10^{-8}.

Magnetostriction with Small Fields.—An *iron* wire containing 0·1 % C, and a wire of *electrolytic* Ni were studied. In each case the curve for magnetostriction as a function of the field is nearly linear, but slightly concave downward, and apparently passes through the origin. For fields of 1, 0·05, and 0·002 gauss, the ratio of magnetostriction to field strength is respectively 3, 2·4, and 4×10^{-9} for Fe, and 2, 1, and 3×10^{-9} for Ni. The probable error is from 7 to 10 %. *The effect of increasing the tension* is to decrease the elongation of both metals. A rod of *bismuth* 8 cm. long was tested in a field of 12 gauss using the resonance method, but gave a negative result, indicating that the effect is at least 10,000 times less than for iron.

The *Pupin wave balance for varying the phase of an alternating e.m.f.* is described. AUTHOR.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1918. *Diffusion of Hydrogen through Iron and Platinum.* **G. C. Schmidt** and **T. Lücke.** (Zeits. f. Physik, 8. 3. pp. 152–159, 1922.)—According to Nernst and Lessing [Abs. 2118 (1902)] if the gas concentration on one side of a Pt plate is maintained constant, the time required for the concentration at the other side of the plate to assume some definite value is proportional to the square of the thickness of the plate. Since the results of their experiments with hydrogen did not accord with this law, these authors concluded that the process is not a true diffusion of the gas, but that the Pt contains channels through which the gas passes. The results of the experiments now described show that if hydrogen is generated electrolytically on one side of an iron plate, the gas makes itself evident on the other side of the plate by a fall in the potential. With thin foil this fall appears immediately electrolysis begins and at first increases rapidly, but tends towards a constant value if the evolution of the gas is protracted. With thicknesses of 0·5–1 mm. the fall in potential is gradual, whilst no effect is observed with metal more than 1 mm. thick. Interruption of the polarising current is followed by rise of the potential, this occurring the more rapidly the thinner the metal plate; the hydrogen evidently diffuses into the liquid. The slow recovery of the potential with thicker sheets of metal corresponds with the slowness with which the relatively larger quantities of hydrogen diffuse away. The rapidity with which the potential falls increases with the current density employed in the electrolysis. When the fall of potential is small, the Nernst-Lessing law is found to hold, so that the passage of hydrogen through iron must be regarded as a true diffusion. Contrary to what was found by Nernst and Lessing, this law is obeyed also in the case of Pt, even with small changes in the concentration, the process here too being one of diffusion. When nickel plates are used the gas passes only with extreme slowness.

As Nernst and Lessing found, the above law holds with palladium, and the reason why this is the case, whereas with thick Pt foil it is otherwise, is that but little of the hydrogen diffusing through the Pd is liberated into the liquid owing to the extremely high capacity for absorbing hydrogen exhibited by this metal. Hence in this case $\partial u/\partial x$ is nearly zero, which is a condition assumed by Nernst and Lessing in deducing their theoretical law. T. H. P.

1919. *Separation of Isotopes by Thermal and Pressure Diffusion.* **R. S. Mulliken.** (Am. Chem. Soc., J. 44. pp. 1033–1051, May, 1922.)—In a previous paper by the author and Harkins [see Abs. 1403 (1922)] a summary of the possible methods for separating isotopes was given. In the present paper, the theory of the method of thermal diffusion and that of the centrifugal method, as applied to the separation of isotopes, are discussed and conclusions reached as to the relative practical value of the two methods. A. B. W.

1920. *Absolute Value of the Energy of the Linkings between the Atoms of Compounds.* **M. Padoa.** (Soc. Chim. Ital., Gazzetta, 51. ii, pp. 239–245, 1921.)—The method of calculation used by Fajans [Abs., 645 (1920)] is substantially that employed by the author, who,

however, assumed the value 42 Cal. for the heat of sublimation of diamond and graphite indicated by Thomsen's results, whereas Fajans, on the basis of relationships established by Grüneisen between the heat of sublimation of a solid monatomic element and the ratio of atomic heat to the coefficient of thermal expansion, concluded that the heat of sublimation of carbon is at least 275 Cal. per gram atom. In spite of the large difference between these two values, both authors conclude that the energy of the linkings between the carbon atoms is almost the same in diamond and in aliphatic hydrocarbons. It seems probable that neither of the above two values is the correct one, and the author considers 150 Cal. to be more nearly the truth; Kohn [Abs. 676 (1921)] arrives at values similar to this. Steiger's results are also discussed.

Taking the value 150 Cal. for the heat of sublimation of 1 gm. atom of carbon and 81·3 Cal. for the heat of dissociation of 1 gm. molecule of hydrogen, the energy of the C—C linking is calculated for the aromatic and aliphatic hydrocarbons previously considered. The results show that the energy of the linking increases from simpler to more complex compounds. The differences of the values referred to graphite and to diamond vary from 5 to about 7 % and are small considering that the side of the hexagon is $6{\cdot}2 \times 10^{-8}$ cm. in benzene and $1{\cdot}45 \times 10^{-8}$ cm. in graphite.

T. H. P.

1921. *Diffusion in Metals in the Solid State and Cementation of Non-ferrous Metals.* I. *Cementation of Copper by means of Ferro-manganese.* **G. Sirovich** and **A. Cartoceti.** (Soc. Chim. Ital., Gazzetta, 51. ii, pp. 245–261, 1921.)—A bar of copper was arranged centrally in a porcelain tube glazed internally and the tube then packed with ferro-manganese containing 5 % of wood charcoal, both these materials being capable of passing through a sieve with 64 meshes per cm.^{2} and of being retained by one of 324 meshes per cm.^{2} The tube was closed by means of rubber stoppers luted with sodium silicate. After the tube had been heated for some hours at 900° in a Heraeus furnace, considerable proportions of the manganese were found to have penetrated the copper. T. H. P.

1922. *Photomicrographic Study of a Series of Drawn Tungsten Wires.* **L. P. Sieg.** (Phys. Rev. 19. p. 273, March, 1922.)—The author has previously reported on the effect of drawing on the coefficient of simple rigidity of ductile tungsten wires [Iowa Acad. Sci., Proc. 24. p. 207, 1917]. In the previously published reports the hypothesis was advanced that if the drawing produced a surface effect, penetrating to a moderate distance, and if this surface state of the wire possessed the higher rigidity, then the results could be accounted for. It remained to examine the wires photomicrographically to test the soundness of the theory. The photographs obtained show a distinct demarcation, in the larger wires, between the surface layer and the central portions of the cross-sections. In the smaller sections, this surface layer occupies almost all the cross-section, and in the smallest wire, the surface structure occupies the whole of the cross-section. The radii of the wires varied from 0·00240 to 0·0227 cm.

While it was clearly possible to differentiate between the two crystal states, it was by no means, even with the highest magnifications, to be certain what this change really represented. The surface structure was such that details could scarcely be made out, whereas the outlines of the crystals in the central portions were relatively large, and clearly distinguish-

able. It is tentatively assumed that the crystals in the surface are extremely small, and separated by an unusually large amount of the so-called amorphous metal. This amorphous state is probably groups of atoms, not sufficient in number to constitute genuine crystals. L. H. W.

1923. *Corrosion of certain Aluminium Alloys.* **L. Rolla.** (Soc. Chim. Ital., Gazzetta, **52**, i. pp. 79–87, 1922.)—The author applies Desch's method of investigating corrosion, in which the metal is made the positive pole in the electrolysis of sodium chloride solution, to various Al-Zn and Al-Mg alloys, which were prepared in a current of hydrogen in the electric furnace.

[With **M. Frassineti.**]—The results obtained with the Al-Zn alloys show that solid solutions of Zn in Al undergo corrosion in such a way that neither of the two components exerts a true protecting action on the other. This result indicates that, although the solution pressure of the Al is greater than that of the Zn, the phenomenon is not electrochemical, but purely chemical in character.

[With **M[ario] Bulli.**]—Two Mg-Al alloys containing (1) 5·68 % Mg and 93·3 % Al and (2) 6·9 % Mg and 92·18 % Al, with small proportions of iron, silica, and carbon, were examined, the latter undergoing the more rapid corrosion. In either case a voluminous precipitate, mostly aluminium hydroxide, was formed, and the proportion of Mg removed was greater than that of the Al. The protective action of the adherent stratum of aluminium hydroxide exerts an important influence on the course of the corrosion, rendering it discontinuous. T. H. P.

1924. *Heat of Transformation of Austenite to Martensite and of Martensite to Pearlite.* **N. Yamada.** (Tôhoku Univ., Sci. Reports, **10**. pp. 453–470, Jan., 1922. Fifty-sixth Report of the Iron and Steel Research Inst., May, 1922.)—Describes a calorimeter devised for measuring heat evolution or absorption at temperatures in the vicinity of 400° C. and gives the results obtained for the dissolution of carbon in iron in the case of six samples of carbon steel. These results show that the heat of dissolution increases linearly with increase in carbon content and amounts to 1130 cals. per gm. of carbon. The results are also given of the determination of the sum of the transformations A3, A2, and of austenite $\rightarrow$ martensite for six samples of steel, obtained by the usual method of mixture. By combining the result of the present experiments with that of Meuthen, the heat of the allotropic transformation (austenite $\rightarrow$ martensite) is found to increase linearly with the carbon and to amount to 5·6 cals. per gm. for eutectoid steel. The specific heats of troostite and pearlite have the same value within the limit of experimental error. The results are considered to confirm Honda's theory of the A2 transformation as being a stepped transformation of austenite $\rightleftarrows$ martensite $\rightleftarrows$ pearlite. C. O. B.

1925. *Effect of Time in Reheating Quenched Medium-Carbon Steel below the Critical Range.* **C. R. Hayward, D. M. MacNeil,** and **R. L. Presbery.** (Am. Inst. Mining Eng., Trans. [5 pp.], Jan., 1922.)—Gives the results of experimental work carried out with a view to supplementing results published in 1916, during the discussion of which evidence was presented which seemed to throw doubt on their accuracy. The steel bars used contained about 0·45 % carbon. The specimens were quenched from 850° C. and then reheated in lots of three for 5, 15, 30, 60, 120, and 240 minutes at

300°, 400°, 500°, and 600° C. and tested for hardness and tensile properties. The results are given in the form of curves which show that even 5 minutes' heating of the quenched steel at 300°, lowers considerably the strength and hardness and increases the ductility. There is a marked increase in ductility in passing from the 400° to the 500° treatment, without an equivalent lowering of strength; it is accompanied, however, by a change from an indefinite to a definite yield-point. The specimens reheated to 600° C. are nearly as ductile as the annealed specimens, but they have an elastic limit about 60 % greater. Reheating the steel for 1 hour is all that is necessary and for temperatures of 400° and below, half an hour's heating is sufficient. C. O. B.

1926. *Thermal Improvement of Aluminium Alloys.* **W. Fraenkel** and **R. Seng.** (Zeits. f. Metallkunde, 12. pp. 225–237, July 1, 1920). **W. Fraenkel.** (*Ibid.*, 12. pp. 427–430, Nov. 15, 1920). **W. Fraenkel** and **R. Scheuer.** (*Ibid.*, 14. pp. 49–56, Feb. and pp. 111–118, March, 1922). **E. Scheuer.** (Dissertation, Frankfurt.)—The papers concern the same series of researches on duralumin, the last papers giving fuller particulars especially of the electrical tests. The presence of magnesium is considered essential, but the paper gives little detail on that point. The 8 alloys first tested contained 1·5 or 3 % Cu, 4 or 8 Zn, 0·5 or less Mg; in further tests alloys with up to 1·9 Mg and 0·5 Mn were used. The specimens are heated up to various temperatures (560° C. max). and quenched in water of various temperatures; the strength is then found to increase in the course of hours or days. The improvement depends upon the conditions, and is destroyed by subsequent reheating. Copper alloys have to be heated to higher temperatures than zinc alloys, but they also bear subsequent heating (even to 280° in some cases) better. When cooled slowly, instead of being quenched, the specimen does not improve. The various tests were made in order to trace the phenomena. The density hardly changed; hardness and torsion tests were found of little use; tensile strength and elongation were determined; metallographic studies led to no final conclusions, no definite bodies were isolated, and characteristic differences between improved and unimproved alloys were not observed. The changes in electric resistance were most striking and these tests, also specific conductivity and thermoelectric force tests, are described in full detail; but the rise in electric resistance did not always go together with an increase in strength. The reheated material has the highest conductivity, material slowly improved at ordinary temperature the lowest; when the quenched material is kept at 100° for some time after quenching, the resistance rises very slowly, but quenching in water at 100° may give full improvement. The highly-heated material was most attacked by hydrochloric acid, and material freshly quenched or allowed to improve at ordinary temperature was least attacked. It is suggested that chemical compounds are slowly being formed after the thermal treatment.

H. B.

1927. *Alloys of Aluminium and Molybdenum.* **H. Reimann.** (Zeits. f. Metallkunde, 14. pp. 119–123, April, 1922.)—Experiments on the preparation of Al-Mo alloys, starting from Al and Norwegian concentrates of molybdenum sulphide containing Fe, S, and Si, but not Cu and As; crystals of pyrite could be seen, but the iron could not be extracted by hydrochloric acid. The alloys were prepared by fusing the Al and then introducing

the ore; they first contained sulphur, but they were free from sulphur when the slag was always tapped off before adding another portion of the ore. Intense heat is liberated during the reaction. Heating and cooling curves and photomicrographs of the alloys were taken. When the Mo percentage exceeded 30, the alloys became exceedingly brittle and were no longer of metallic character. There are probably two or more Al-Mo compounds; the first formed has a very high melting-point and is surrounded by the second. Molybdenum is little soluble in fused Al; the cooled melts remain in a semi-fluid state over large temperature ranges. The lower Mo-alloys are quite liquid at 1100°. A hypothetical diagram of the system Al-Mo is given. H. B.

1928. *Discussion of the Slip Interference Theory of Hardening.* **P. D. Merica.** (Chem. and Met. Eng. 26. pp. 881–884, May 10, 1922. Paper read before the Am. Inst. of Mining and Met. Eng., Feb., 1922.)

1929. *Studies on Solubility.* IV. *Principle of the Specific Interaction of Ions.* **J. N. Brönsted.** (Am. Chem. Soc., J. 44. pp. 877–898, May, 1922.)

1930. *Influence of Telluric Acid on the Potential of a Silver Anode.* **F. Jirza.** (Zeits. Elektrochem. 28. pp. 186–192, April 1, 1922.)—While the potential at a Pt anode is markedly increased by the presence of F ions, at a silver anode, halides in general are found to depolarise in an alkaline electrolyte and to displace the decomposition voltages towards less positive values. The max. depolarisation is obtained with iodide, while fluoride generally increases slightly the oxidation potential. In an alkaline solution alone the oxide Ag_2O_3 is formed, while with halides Ag_2O_2 is given under conditions of max. polarisation, and with telluric acid Ag_2O. J. N. P.

1931. *Liberation of Electrolytic Gas from Aluminium Electrodes by Alternating Current of* 50 *Periods.* **A. Günther-Schulze.** (Zeits. Elektrochem. 28. pp. 126–129, March 1, 1922.)—Two equal Pt electrodes which yield hydrogen and oxygen with direct current do not liberate gas with alternating current of 50 periods per sec., because, it is said, the gases produced during one phase are reduced again in the next. The author makes calculations on the density of the gas film formed and the diffusion of the hydrogen into the Pt kathode in solutions of $NaPO_3$. When the Pt is replaced by Al, even weak currents cause liberation of gas from both the electrodes. The generation soon comes to a stop in sodium carbonate or borate, in which the Al electrode undergoes formation, but not in $NaPO_3$, in which this formation is very slow. In these latter solutions with equal Al electrodes the decomposition by currents of 50 periods proceeds, as if each phase were acting independently; there is no evidence of depolarisation. In explanation the author refers to his views on the action of Al valves. When the electrolyte is copper sulphate, copper is deposited on both the Al electrodes, but it cannot adhere to the porous oxide film and sinks to the bottom of the cell [see Abs. 1645 (1914)]. H. B.

1932. *Behaviour of Electrolytic Rectifiers at High Frequencies.* **A. Günther-Schulze** and **E. Alberti.** (Phys. Zeits. 23. pp. 188–191, April 15, 1922. From the Reichsanstalt.)—It is shown that in Al-valve cells with molten potassium nitrate as electrolyte, the rectification effect

still holds at frequencies of 3×10^5 and over: Braun-tube oscillograms are given in illustration. This is regarded as a confirmation of the view that valve action is not a process of splitting-off ions, but rather can be explained on the basis of their electrostatic capacity combined with their minimum voltage. L. H. W.

1933. *Crystallisation of Electrolytic Metal Deposits at High Current Densities: Lead.* **A. Günther-Schulze.** I. (Zeits. Elektrochem. 28. pp. 119–122, March 1, 1922. From the Reichsanstalt.)—The crystal growth in preferential directions may have two causes, a geometrical and a crystalline. In order to eliminate the former, it might be thought best to use a vertical cylindrical cell, the top and bottom serving as electrodes, in which the electrolytic stream-lines would be parallel. This arrangement is bad, however; when deposition has favoured some spot on the kathode for some reason, that spot will grow in the direction of the stream lines because the current density will be increased. It is better to make the kathode a small sphere, surrounded by a much larger anode sphere. For experimental convenience the spheres are reduced to shallow troughs. In such a cell, filled with a saturated solution of lead nitrate—which is known to yield needle crystals of lead at fairly high current density—one crystal or a whole wreath of crystals will shoot out radially, and they will all grow practically at the same rate, depending upon the current intensity. The addition of sodium acetate to lead acetate solutions diminishes this rate of growth, because the concentration of the lead ions is decreased; when copper ions are present, lead is practically alone deposited so soon as the current density exceeds a certain value.

Maximum Rate of Crystal Growth and Hydration of the Metallic Ions. (*Ibid.*, pp. 122–126, March 1, 1922.)—When the current intensity was increased by 30 %, the rate of crystal growth in one direction increased eightfold. The rate is limited by the saturation current, and is not the same in different directions. In saturated lead nitrate the maximum rate of growth of lead crystals is 0·206 cm. per sec. at ordinary temperature; that would correspond to a mean period of $1 \cdot 5 \times 10^{-7}$ sec. for the deposition of one lead ion and to a current density of 220,000 amps./dm.^{2} in the axis of the growing crystal. The author makes an attempt to connect the preferential growth in one direction with the hydration of metallic ions. When an ion is to be joined on to the already formed crystal, the water molecules bound by the iron have to be squeezed away; that requires a certain energy and time, and the water molecules are not held with the same forces in the three directions, if we assume the lead ion to be an ellipsoid. Experiments on complex nitrate solutions are mentioned in support of this view. H. B.